APPLIED HYDRAULICS

THE MAGAZINE OF FLUID POWER TRANSMISSION

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ECEMBER, 1949

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YDRAULIC CIRCUITS

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YDRAULIC CONTROLS

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LECTRICAL AND LECTRONIC CONTROLS

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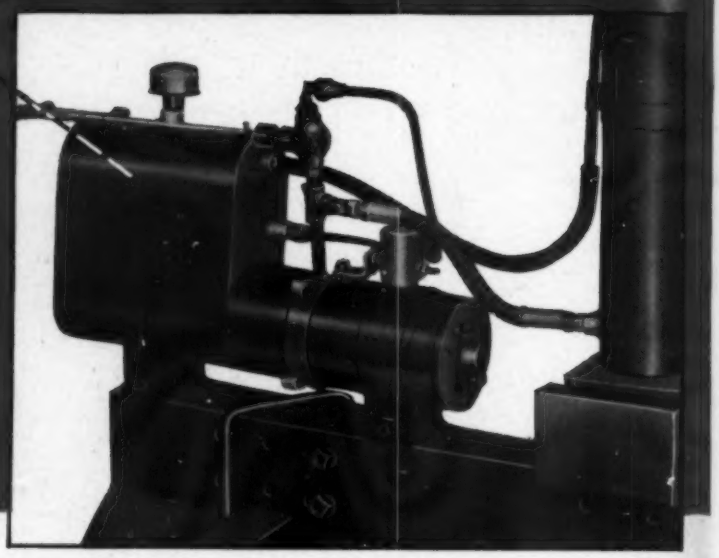
A Dump Truck on a ½ Ton Pick-Up



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DECEMBER, 1949
Vol. 3 No. 11

APPLIED HYDRAULICS

The Magazine of Fluid Power Transmission

FRONT COVER: Model C-121A Constellation, used by the Military Air Transport Service, is the military counterpart of the Lockheed 749 commercial airliner. The story of the development of the flight control booster system of this airplane is told beginning on page 20.

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Published monthly by The Hydraulics Publishing Co., an affiliate of Industrial Publishing Co., publishers of Commercial Refrigeration and Air Conditioning, Die Castings, Flow, Industry & Welding, Occupational Hazards, and The Taxicab Industry. Member, Controlled Circulation Audit, Inc., and National Business Papers Association.

Subscription rates: United States and possessions—$3.00 per year, $5.00 for 2 years; Canada—$4.00 per year, $6.00 for 2 years; Foreign—$5.00 per year. Single copy price, 30 cents. All subscriptions subject to individual acceptance by the publisher.

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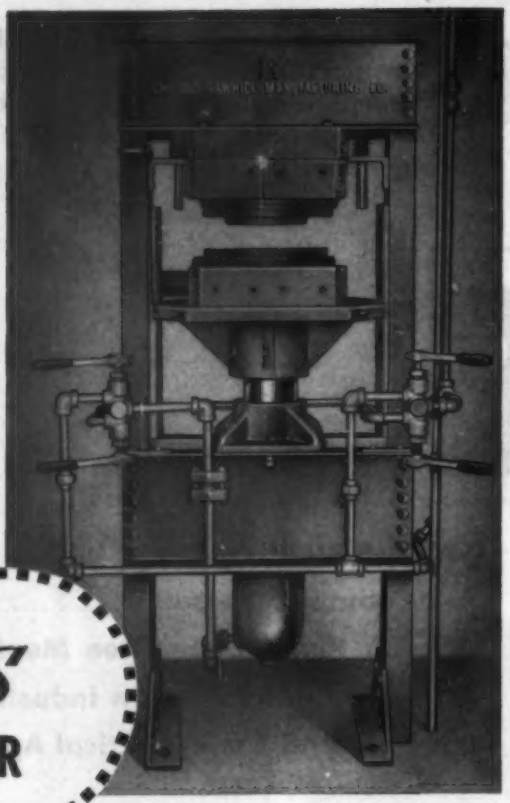

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LETTERS *to the Editor*

We are pleased to note from notes in both your October and November "Letters to the Editor" column that you are to start a new department relating to practical operating and maintenance suggestions for pneumatic and hydraulic equipment. We are enclosing a suggestion that both we and our customers have found worthwhile.

J.M.G.

Thanks; we have received many letters and a number of very good ideas, some with sketches and detailed procedures, for our new "How to Do It" or "Here's How" department. This new department is scheduled to begin in our next issue. See also the announcement elsewhere in this issue, offering cash prizes for published items.*

Upon reading your issue for October, I noticed the article, "Economies in Power for Machine Tools" by W. P. Hall. From this article, we became interested in the use of accumulators and believe we could profit from their use on some of our installations. We would like to secure the names of some of the companies who make accumulators in order to obtain more information about them.

W.H.L.

Names and addresses of companies who make accumulators, both bladder and the new cylindrical type, have been sent to you. Accumulators are finding more and more uses in oil pressure systems, where they effect economies in equipment sizes, as well as in gas pressure systems where surges are troublesome.

In the October issue of "Applied Hydraulics" there appeared an article, "The Correlation of Hydraulic and Electric Control Circuits", by D. E. Gerberich. The author used J.I.C. symbols for both the hydraulic and electric circuits. The writer is unfamiliar with these symbols and would appreciate your advising where it would be possible to obtain an explanation or table of these symbols.

D.J.

These symbols are a part of the J.I.C. Hydraulic Standards for Industrial Equipment, copies of which may be obtained from J. C. Rauss, Production Engineering Section, General Motors Corporation, 15-228 GM Bldg., Detroit 2, Mich. They have also been reprinted by Miller Motor Company, 4029 North Kedzie Ave., Chicago 18, Ill. (as part of the complete Standards) and separately by the Oilgear Company, 1564 W. Pierce St., Milwaukee 4, Wisc.

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* See page 19.

SAE A-6 Meeting

APPROXIMATELY 100 HYDRAULICS engineers from the aircraft industry and government services were present at the semi-annual meeting of SAE Committee A-6, Aircraft Hyraulic and Pneumatic Equipment, held November 2-4 at the Mayflower Hotel, Washington, D. C. Under the direction of Chairman B. R. Teree, the Committee acted on 44 items during the three day session.

In accordance with previous practice, a group of West Coast aircraft hydraulic engineers held an earlier meeting on October 18 at Northrup Aircraft, Inc., Hawthorne, Calif., for the purpose of reviewing the agenda and to reach agreement on the most important items. These meetings have proved quite valuable in reducing the discussion at the larger A-6 meetings and in providing a means by which those companies not represented at the A-6 meetings may express their views.

This group devoted most of its time to consideration of the proposed "c" revision to AN-H-2, General Specification for Aircraft Hydraulic Systems and Installations. A total of 42 changes were agreed upon for recommendation to the Military Services and the rest of the aircraft group. Other items discussed were: 3000 psi line type filters, on which recommendations for impulse testing were made; AN819 aluminum bronze coupling sleeves; AN 6287 air valve; and "Yellow Dot" approval problems. All present agreed that much confusion exists in interpretation of this latter item and that a standardized definition of the meaning of the various approval classifications was essential. Attendance at this meeting included Warde Parker, Northrup, acting chairman; Frank Mittell, North American; David Grant and W. Boals, Hughes Aircraft; Frank Murphy and Carl Chambers, Douglas, Santa Monica; John Bloom and Harry Cornish, Douglas, El Segundo; Jack Hudson, Consolidated-Vultee; and Fred Hosterman, Lockheed.

Probably the most important items discussed at the A-6 meeting again was the proposed "c" revision to AN-H-2. Almost eight hours were devoted to the consideration of this document which controls the de-

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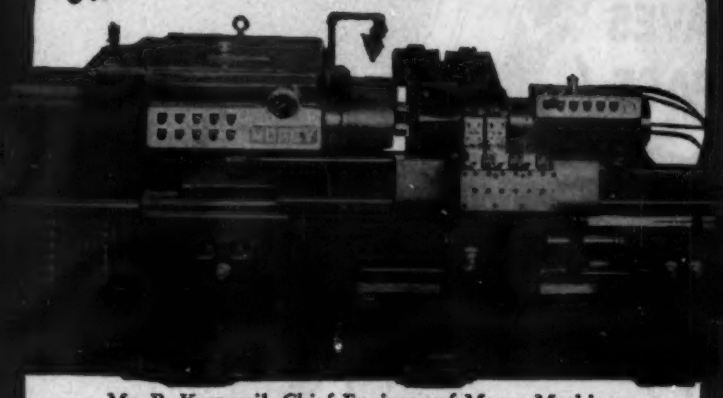

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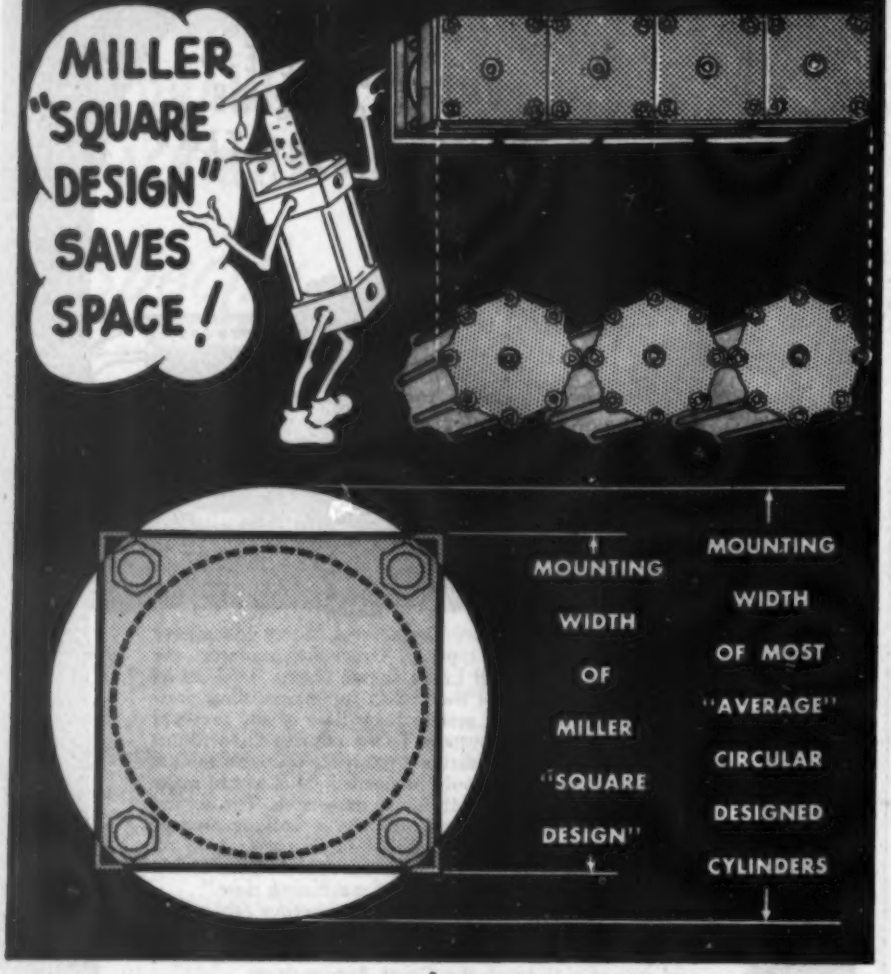

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sign and installation of the complete hydraulic system and its components. Many compromises and concessions by both the Military Services and the aircraft industry were required before agreement was reached on the final form of this 32-page document. Representatives of the Services and the Aeronautical Standards Group announced that they would expedite the processing of the changes and hoped to have the final revision printed within the next 30 days.

For pneumatic systems, the counterpart of AN-H-2 is specification AN-P-86. This document was discussed with a view toward bringing it up to date. Mr. A. H. Hobelman of the Walter Kidde Company was assigned the responsibility for revising the specification, based on an industry-wide survey which he had conducted. Messrs. Mileti and Bayuk of Air Material Command reported on the air compressors now being developed under Air Force contracts. Reports were distributed to the airframe company representatives, outlining the advantages of pneumatic systems and listing the characteristics of the various compressors which now or soon will be available.

Important changes were also made to specification AN-P-74, which covers the design of packing glands and installation of both "O" and "V" ring packings. The major discussion was concerned with the definition of design and breathing clearances, as well as the establishment of suitable maximum values for each. Mr. F. W. Murphy of Douglas had previously conducted a survey to obtain industry opinion on the proper figures. The survey indicated general agreement on the maximum design clearance, but rather wide variation in breathing or total clearance. It was finally agreed that only design clearance should be limited by the specification, since the clearance due to breathing under pressure is generally limited by the use of normal design margins in the strength of a cylinder barrel.

Envelope drawings for both the new, smaller size unloader valves as well as for cylindrical piston-type accumulators received critical attention. It was found necessary to make a slight increase in the unloader valve envelope to permit universal

location of the mounting holes. The cylindrical accumulator, which is a new item, was not given final approval; however, a subcommittee was appointed to coordinate the uncertain dimensions with those of manufacturers who had indicated an interest in this project.

Considerable discussion centered around the materials used for high pressure tubing and the proper test criteria to be used for determining the suitability of any new material. Mr. W. V. Scholz of United Air Lines reported that a fatigue life test simulated by ten million impulse cycles was considered necessary by the commercial operators in order to insure that the tubing would last for the life of the airplane. Such a test obviously requires very high speed cycling and it was agreed to investigate the equipment now used by the JIC group for such work.

In accordance with the practice established at the previous Dayton meeting, Mr. J. M. Kidd, Chairman of SAE Committee A-1, Aircraft Pumps, and Mr. L. J. Henderson, Chairman of SAE Committee A-3, Fittings and Hose Assemblies, reported on the activities of their respective groups held on the two previous days.

Spokesmen for the Government agencies present included L. M. Chattler of the Bureau of Aeronautics, E. M. Polk of Air Material Command and R. N. Stickney of the Aeronautical Standards Group.

A-6 Committee members present included: Chairman B. R. Teree of the New York Air Brake Company; B. N. Ashton of Electrol, Inc.; J. W. Kelly of Adel Precision Products Corp.; J. M. Kidd of Glenn L. Martin Co.; J. P. Kovacs of Purolator Products Inc.; F. A. Lewis of Linear, Inc.; F. W. Murphy of Douglas Aircraft Co., Inc.; F. O. Hosterman of Lockheed Aircraft Corp.; H. P. Kupiec of Air Associates, Inc.; F. H. Pollard of Republic Aviation Corp.; W. V. Scholz of United Air Lines, Inc.; and D. E. Leach of Chance Vought Aircraft. R. C. Bumb of North American Aviation was unable to be present but was represented by Frank Mittell.

The Chairman announced that the next meeting of the A-6 Committee would be held in New York City, in April 1950, details of time and place to be announced later.

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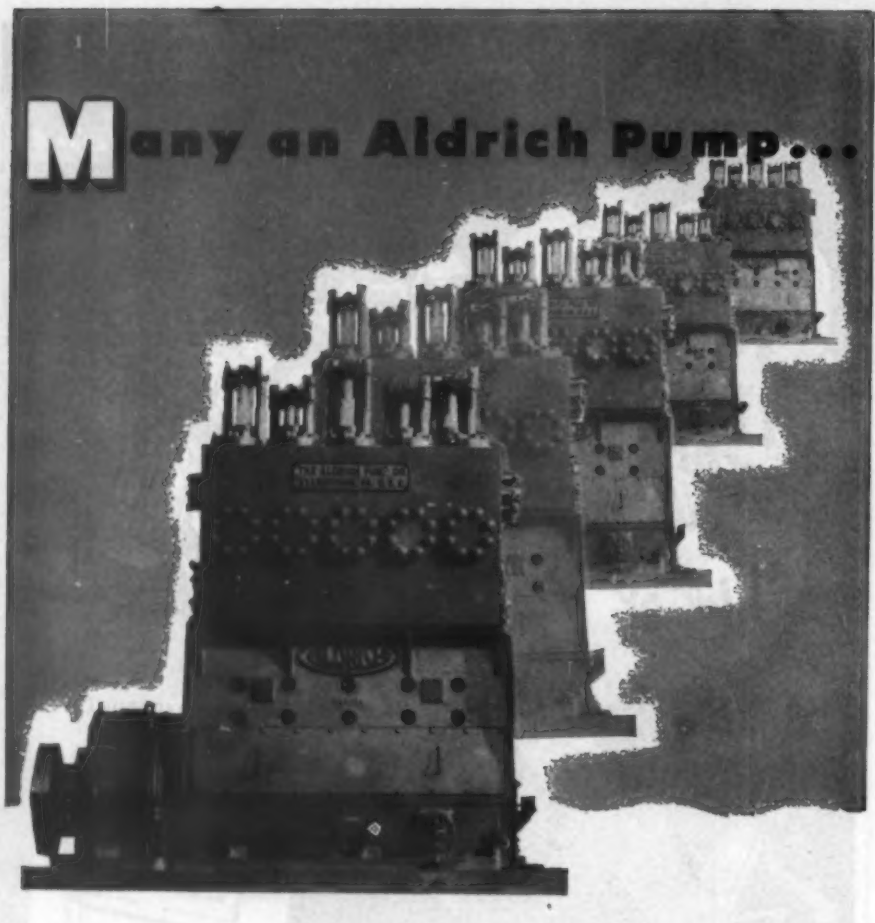

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A-3 Committee Meets

UNDER THE CHAIRMANSHIP OF L. J. Henderson of the Aeroquip Corporation, SAE Committee A-3, Aircraft Fittings and Hose Assemblies, held its meeting at the Mayflower Hotel, Washington, D. C., on October 31 and November 1, immediately preceding the meeting of the A-6 Committee. Approximately 25 items involving the aircraft fuel, hydraulic and power plant groups were discussed.

Among the items of major importance to hydraulic engineers was that of AN-H-24 and AN-H-28 hose assemblies. In order to reduce the possibility of overlapping standards and the resulting confusion in manufacturing and maintenance organizations, it was agreed to limit the future use of AN-H-24 single wire braid hose to services in which the pressure does not exceed 2000 psi. These assemblies would make use of end fittings assembled over the outer cover, eliminating some of the present types which grip the wire braid. All usage for pressures over 2000 psi will require the AN-H-28 double wire braid assemblies. It was considered that this change would permit the reinstatement in specification AN-H-24 of the requirement for impulse testing with pressure peaks equal to 150 percent of the nominal hose pressure rating. During the interim period, until AN-H-28 assemblies in the —4 and —5 sizes can be qualified, it will be necessary to continue the use of AN-H-24 hose at presures up to 3000 psi. However, it was felt that the new assemblies will be forthcoming in a relatively short time.

Specification AN-C-150, covering protective and shipping closures, also received extensive revision. The major changes involved a more complete set of specifications covering the use of both plastic and metal closures. Also included was a complete set of qualification tests, permitting the later issuance of an ANA Bulletin of approved sources.

Of interest to the fitting manufacturers were a large number of items including forged shapes, sandwich type bulkhead fittings, the 814 plug and bleeder fittings and a summary of the problem of statistical control as a means for inspection of fittings.

Developments on these and other subjects were too numerous and extensive to be reported here.

Chairman Henderson submitted a report to the A-6 Committee on those items of particular interest to the hydraulics and pneumatics group.

F.O.H.

Aircraft Pump Committee Meeting

THE SAE COMMITTEE A-1, AIRcraft Pumps, of which J. Milton Kidd, hydraulic engineer, Glenn L. Martin Co., is chairman, met on November 1 at the Mayflower Hotel, Washington, D. C. Following the precedent of the successful Dayton meeting, the Committee previewed a number of items scheduled for discussion at the A-6 Committee meeting that were of particular interest to the builders and users of aircraft hydraulic pumps.

Mr. Jay M. Roth of Mechanisms Co. reported on the results of a survey concerning a proposed test on pressure pulsation for inclusion in AN-P-11. Changes that might be necessary to the same specification due to the development of high speed hydraulic pumps were also discussed. Mr. Frank W. Murphy of Douglas Aircraft reported on the status of a proposed specification on an electric motor driven hydraulic pump. Mr. K. I. Postel of Vickers, Inc., reviewed the status of a proposed specification on hydraulic motors.

At the proposal of Mr. M. W. Huber, New York Air Brake Co., a discussion was held relative to the development of component parts for 5000 psi hydraulic systems. Mr. M. Caserta of M. C. Manufacturing Co. reported on recommended changes in the current specifications for fuel pumps for reciprocating engines; Mr. Joseph A. Mileti of Air Materiel Command presented a tentative draft on a specification for small electric driven vacuum pumps; and the need for specifications for water injection pumps was discussed.

As previously, Chairman Kidd reported briefly to the A-6 Committee, which met on succeeding days, on the highlights of his Committee's discussions and recommendations.

What is your I. Q. on Hydraulic Filtration?

Q What causes more hydraulic maintenance troubles than all other causes combined?

A Unclean hydraulic oil.

Q What are the difficulties unclean oil may cause?

A Scoring of cylinders, valves and sliding or rotating surfaces.

Leakage of oil through scoring, with loss of power thereby. Slow operation because impurities make oil sluggish and slow to flow through small ports, orifices and tubings. In failing to enter working cylinders quickly and in proper volume, impure oil reduces the prompt accuracy and fingertip response characteristic of efficient hydraulic equipment.

Excessive heating results when pressure is dissipated through leakage instead of in productive work.

Q How does dirt get into hydraulic oil?

A Oil can pick up impurities as it is poured into containers which themselves may not be absolutely clean. The air in most industrial plants usually carries moisture and abrasive dusts. Chips, filings, threads, lint and other foreign matter is apt to work into hydraulic systems. Paint on inner walls of reservoirs can flake off, rubber linings of flexible connections can decompose under long exposure to hydraulic fluids and such material enter the system. Water contamination can cause rust.

Q How can impurities be kept from entering oil?

A Frankly, all impurities cannot be prevented from entering hydraulic oil. Clean tight storage containers will start the operation, with a minimum of impurities, but oil may gather some impurities during operations of the most perfect hydraulic machine.

Q Can impurities be removed from dirtied oil?

A Yes. A good filter at the intake will provide continuous removal of impurities as they accumulate.

Q What constitutes a good filter?

A A good filter does the job for its particular machine dependably, with little necessary care, and does not interfere with the flow of the filtered oil. To do this, it must have the proper size filtering mesh, must have enough filtering area to allow an adequate flow rate at low pressure losses with long periods of operation between changing and cleaning of filter units. It must be easy to install, clean, disassemble and reassemble.

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National Conference on Industrial Hydraulics

THE FIFTH ANNUAL NATIONAL Conference on Industrial Hydraulics, held at the Sheraton Hotel, Chicago on October 26 and 27 was, by general concensus, the most successful meeting to date. A record registration of 357, nearly 25 percent greater than last year's meeting, reflected the increasing importance which the industry is placing on these meetings.

Four technical sessions, morning and afternoon of both days, heard a total of 14 papers (a specially prepared article based on Mr. Richolt's paper is in this issue, as well as abstracts of other papers in the Hydraulic Digest department), grouped respectively as recent developments, hydraulic equipment components, design considerations and hydraulic circuit performance.

At the first luncheon session, Rudolph Esch, sales manager, industrial division, Vickers, Inc., answered the question, "What is Industrial Hydraulics?" by a review of the development of hydraulic components and their application to industrial equipment. He gave an optimistic picture of the future of hydraulics in industry. At the second luncheon, which was devoted to a discussion of the JIC Hydraulic Standards for Industrial Equipment, Don Morrell, supervisor, Standards and Control Applications, Ford Motor Co., discussed the progress that has been made in the design, operation and maintenance of hydraulically actuated machines as a result of the JIC, illustrating his talk by convincing photographs of hydraulic applications and installations of machines before and after the JIC standards were in effect. Ernst Weidmann, chief engineer, the Oilgear Co., discussed the effects of JIC Hydraulic Standards on the manufacturers of industrial equipment, pointing out the excellent reception the users of hydraulic systems have given the Standards and the fine support which the manufacturers of such systems, despite hardships in some cases, have given to expedite delivery of hydraulic equipment to meet JIC standards.

The All Society banquet, held on the first evening, was attended by over 400 persons. Henry T. Heald, president, Illinois Institute of Technology, spoke on "The Path to Achievement", reminding his audience of the importance of teamwork of research, design, manufacturing and production. He cited the surging growth of the hydraulic industry as an example of this teamwork. Andrew Kalitinsky, chief engineer, NEPA Project, Fairchild Engine and Airplane Corporation, kept his audience fascinated as he developed his subject, "Atomic Power and Aircraft Propulsion", first, by outlining the basic concepts of nuclear physics with the assistance of slides and then touching on the general problems, which are enormously difficult, of applying atomic energy to aircraft power plants.

The National Conference on Industrial Hydraulics is sponsored by Armour Research Foundation and Graduate School of Illinois Institute of Technology with the active cooperation of Western Society of Engineers, American Society of Lubrication Engineers and the local sections of American Society of Civil Engineers, American Society of Mechanical Engineers, Society of Automotive Engineers, American Institute of Chemical Engineers and Institute of Aeronautical Sciences.

Fig. 1. Seated at the speaker's table at the All Society Banquet are, left to right—Charles J. Clark, chairman Promotion Committee; LeVan Griffis, member of Conference Board of Governors; Gustav Egloff, Universal Oil Products Company; Otto J. Maha, Conference Director; Andrew Kalitinsky, Chief Engineer, NEPA Project, who addressed the meeting; Edgar A. Jett, II, toastmaster; Henry T. Heald, president, Illinois Institute of Technology; and Warren E. Wilson, Past Conference Director.

Fig. 2. Conference Director Otto J. Maha, right, confers with W. E. Mahin, director of research, Armour Research Foundation of Illinois Institute of Technology.

Fig. 3. Rudolph Esch, industrial division sales manager, Vickers, Inc., addressing the luncheon session, answering the question, "What Is Industrial Hydraulics?".

By FRANK FLICK

Boosters and their practical application

THE DESIGN OF A NEW LINE OF low cost, production manufactured fluid pressure boosters that develop dual pressures and that hold their pressures indefinitely has opened up a wide range of applications for boosters on nearly all types of industrial equipment.

For many years booster applications have been common in a few restricted fields where the volume demand for one or two sizes and types was sufficient to warrant their production in quantities large enough for economical manufacture. Now, by utilizing interchangeable standard parts employed in standard production air and hydraulic cylinders, one or more boosters of any size can be economically manufactured.

Since the early type boosters held pressures for only seconds at a time, their field of application was limited. However, the postwar development of booster design utilizes seals that hold pressures indefinitely.

The early booster circuits were limited to units that developed single pressures only. The economical application of single pressure circuits, especially in air driven boosters, was limited to fields where only small volumes of fluid were required.

Recently developed dual pressure circuits are economical both from the standpoint of initial and operating costs where long, low pressure approach strokes and short, high pressure working strokes are required, such as on plastic molding presses, clamping devices, punching, shearing, crimping, riveting, welding and similar applications. The single pressure and dual pressure boosters are similar, the difference is in circuit application. In general, in cases where the low pressure approach stroke of the working cylinder is relatively long in comparison to the high pressure work stroke, the dual pressure booster circuit is much more advantageous because the booster required is smaller and saves considerable air over a single pressure circuit, the savings in air being in direct proportion to the ratio of the length of the approach stroke to

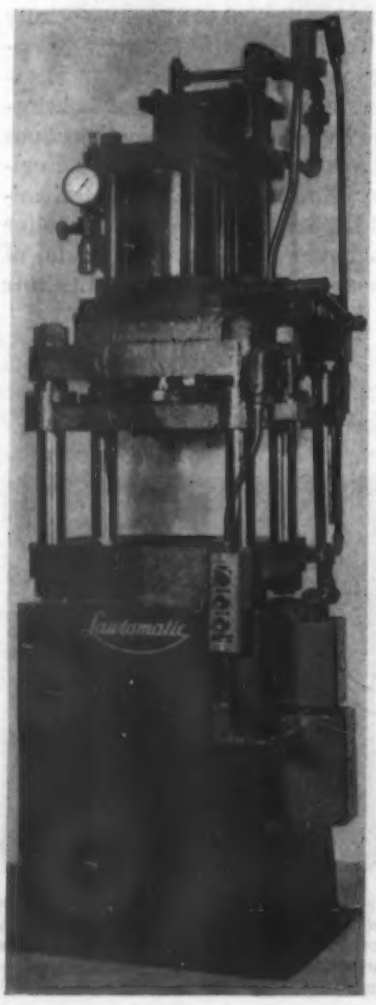


Fig. 1. The "Lawtomatic" plastic molding press, 30 to 50 ton capacity, is operated by a booster from 80 psi plant air line pressure. The manufacturer is C. A. Lawton Co., De Pere, Wisc.

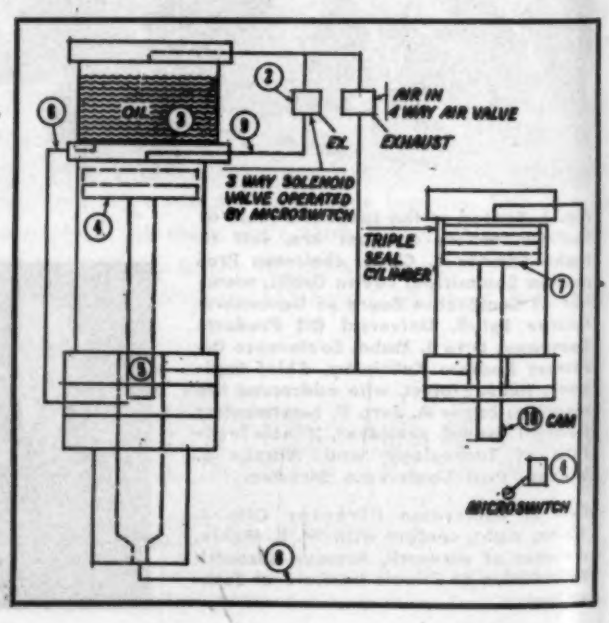


Fig. 2. Diagram of a dual pressure booster circuit. The low pressure medium enters booster at 9, to drive the large diameter piston 4, which, in turn, drives the smaller diameter hydraulic ram 5 and develops high pressure fluid in line 8. When operating conditions justify, air could be supplied directly from four-way valve to line 9, by eliminating solenoid valve 2 and the air line to the top of the reservoir.

Single and dual pressure booster circuits with single stroke units that supply, at one stroke, the full pressure and volume requirements of the working cylinders they operate are described and typical applications suggested.

the working stroke. Single pressure boosters tare generally used when small volumes of oil or where extremely high speeds are required.

The circuit shown in Figure 2 is that of a dual pressure booster. By omitting valve 2 and supplying air directly from four-way air valve to line 9, and by omitting the top supply line to reservoir 3, the system becomes a single pressure booster circuit.

Dual Pressure Circuit

A typical plastic molding press application utilizing the dual pressure booster circuit is shown in Figure 1. Figure 2 is a schematic of the circuit. This press utilizes an 8 in bore high pressure hydraulic cylinder 7, operating at 2000 psi and developing 50 tons working pressure. The hydraulic cylinder has a total stroke of 3 in and the operation requires a 2½ in low pressure approach stroke and a one-half in high pressure working stroke. A dual pressure booster driven by 80 psi plant air line input pressure supplies both the low pressure and high pressure fluid for this cylinder. The booster itself consists of a 10 in diameter x 8 in stroke air cylinder driving a 2 in hydraulic ram.

Air pressure (80 psi) on the tank or reservoir 3 supplies 80 psi oil for the entire approach stroke of the cylinder through the by-pass line 6, past the hydraulic ram 5 and into the working cylinder. At the end of the approach stroke, the press cam 10 trips a micro switch 1, opening the three-way valve 2, to supply air to the booster cylinder 4. As the booster ram moves forward it produces the high pressure requirement and at the same time blocks off the low pressure oil passage 6 to prevent high pressure backup into the tank. Other devices such as sequence valves or pressure switches can be used in place of the micro switch to kick in the high pressure booster.

The forward and retraction stroke of the press shown in Figure 1 is accomplished in 1½ seconds, so that if no pressure-holding time is required, the press is capable of operating at 40 strokes per minute.

If a hydraulic pump circuit were used, a pump capacity of approximately 50 gpm would be required to obtain this same speed.

In most pump circuits, when a press of this type is required to hold pressure during the curing operation, the pump operates against the pressure relief valve, causing power loss and the generation of considerable heat. On the other hand, when the press is operated by a booster, no motion is required by the booster to hold pressure indefinitely. No heat is generated and no power is wasted. To drive the hydraulic cylinder of the press with a single pressure booster would require five times the volume of air per stroke and a booster six times as large as for the dual pressure booster. To obtain the 50 ton working pressure capacity of the press directly from an air cylinder would necessitate the use of a 38 in bore air cylinder working at 80 psi and five times as much air per stroke.

From this example and comparison, it is easy to understand why the dual pressure booster is so economical and so ideally suited for applications requiring a long low pressure

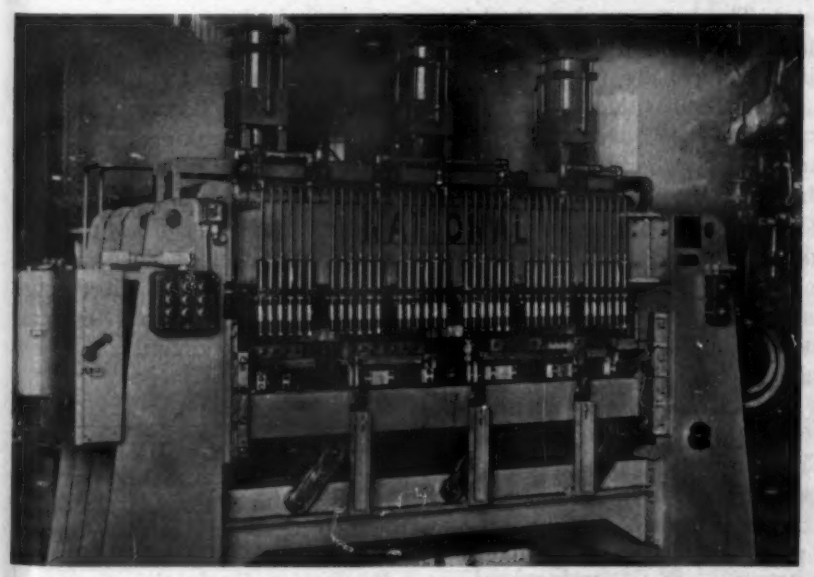


Fig. 3.—Three boosters, top mounted, each drive 12 welding guns simultaneously in this 36 hydraulic cylinder welding gun machine built by National Electric Welding Machine Co., Bay City, Mich.

approach stroke and a relatively short high pressure working stroke.

The input pressure range is up to 200 psi air and up to 3000 psi hydraulic. Hydraulic output pressures range from 200 psi to 10,000 psi hydraulic or more. Boosters can be driven by either air or fluid media and output pressure is always hydraulic.

Single pressure boosters, in general, are faster than dual pressure boosters and, for small volume requirements, can be operated at speeds up to 400 strokes per minute. Single pressure boosters are used instead of dual pressure boosters when the approach stroke is short in comparison to the high pressure working stroke or, as noted previously, where the volume required for the total booster stroke is relatively small.

To save space or weight or where portability is desired, a booster-driven hydraulic cylinder is frequently used instead of an air cylinder. In these instances, the booster can be installed in practically any desired remote location in reference to the hydraulic working cylinder. The sole limitation on location is that the booster should always be installed above the level of the working cylinder in order for the circuit to be self-bleeding and self-filling.

The same speed control methods are available for any booster that drives a hydraulic cylinder as for pump driven hydraulic cylinders. Flow control valves and by-pass valves may be used to control cylinder speed for any portion of the stroke and to provide rapid advance for any other portion of the stroke.

Hydraulic Cylinder Return

The return of the hydraulic cylinder in air-driven booster circuits is accomplished by any one of the following means: (1) by weights; (2) by springs; (3) by air in conjunction with a triple seal type hydraulic cylinder which has a piston cup arrangement that prevents any air from entering the hydraulic circuit; (4) by an oil tank connected to the return side of the hydraulic working cylinder with air pressure applied to the top of the hydraulic tank (special baffling is required for high speed operation to prevent foaming when this method is used); (5) by a separate air cylinder; or (6) by a separate air-driven hydraulic booster. The last named method is particularly adaptable where higher return pressures are required than can be supplied with the plant air line pressure.

An interesting booster application is shown by the illustration, Figure 3. Three boosters are mounted on a welding machine, each booster driving 12 hydraulic cylinder welding guns simultaneously. Except volume requirements, there is no limit to the number of hydraulic working cylinders that can be driven by a single booster.

The simplicity of boosters and of booster circuits recommends their use in plants that do not have qualified personnel for servicing ordinary hydraulic pump installations. Because of this simplicity and because they have so few moving parts, maintenance costs of boosters must necessarily be low.

When cylinders in a hydraulic circuit operate other than simultaneously, a separate booster should be used for each working cylinder or group of working cylinders that operate simultaneously. This arrangement permits the use of low pressure valves for the input media of the booster, eliminating all high pressure hydraulic valving ordinarily encountered in pumping circuits.

Hydraulic Seminar Continues

THE MONTHLY SEMINAR MEETINGS being held by the Committee on Hydraulic and Pneumatic Systems (reported in the August issue of APPLIED HYDRAULICS, pp 24-25), are being continued, according to an announcement by W. J. Williamson, secretary. Howard Field, Jr., is chairman and J. S. Newton is assistant chairman of this Committee which is co-sponsored by five Divisions of the Southern California Section of A.S.M.E., the A.S.C.E., the I.A.S., the S.A.E., the A.R.S., and the A.I.E.E.

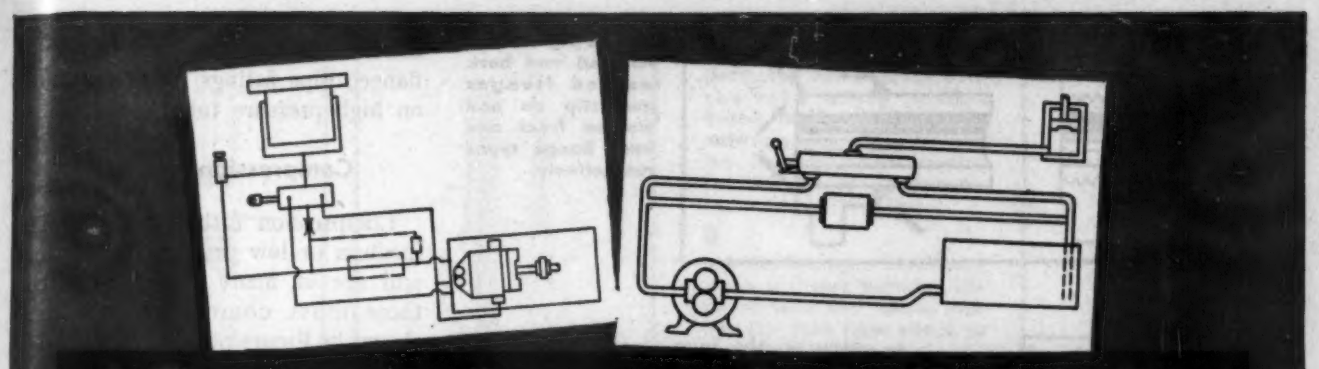
So much interest was developed by the six monthly seminar meetings, April to September, that the Committee decided to continue the meetings with a new series which will emphasize the practical applications of hydraulic and pneumatic systems in industry.

The first meeting of the new series was held October 26th at the Mechanical Engineering Building, California Institute of Technology, Pasadena, Calif. George P. Sutton, supervisor of Rocket Motor Development, North American Aviation, Inc., and president of the Southern California Section of the American Rocket Society, spoke on "Hydraulics of Liquid Propellant Rocket Motor Systems". Mr. Sutton discussed the general hydraulic requirements of liquid propellant systems, some of the special problems peculiar to rockets, and some typical system configurations.

On November 30, Dr. Henry Fuchs, Assistant Chief Engineer, Preco, Inc., spoke on "Energy Relations in Hydraulic and Pneumatic Systems." The following meeting, December 14, the speakers will be Charles Drexel, Development Engineer, and Ivan Speer, Preliminary Design Engineer of Airesearch Mfg. Co. Their papers will be on the subjects "Operation and Design of Pneumatic Components of Aircraft Air Conditioning and Pressurization Systems", and "Aircraft Pneumatic Systems for Continuous Transmission of Power." At least three more meetings will be held.

The committee invites all engineers and others engaged in or interested in any phase of hydraulics or pneumatics to attend these seminar meetings. They also would appreciate any suggestions or help from anyone in a position to assist in their more important work of preparing a "Recommended Good Practice Manual" for the use of designers of hydraulic or pneumatic systems or equipment. Please send suggestions for the Manual or inquiries for information about the seminar meetings to the secretary of the Committee, William J. Williamson, Aerophysics Laboratory, North American Aviation, Inc., Downey, Calif.

The revised edition of JIC Hydraulic Standards for Industrial Equipment is expected to be ready for distribution by the first of the year. Copies may be secured from J. C. Rauss, Production Enginering Section, General Motors Corporation, 15-228 GM Bldg, Detroit, 2, Mich.



A Beginner's Course in Basic Hydraulics

Chapter IV

Part 2

FLANGED AND COMPRESSION FITTINGS

The varieties and uses of flanged and compression fittings; flaring; hydrostatic testing.

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Flanged Fittings

Varieties and uses. Flanges or offsets of many different kinds can be fitted to pipe ends in various ways so as to hold them together. They are commonly used on high pressure lines and large diameter pipes. The most usual type consists of two cast or forged flanges (Figure 55), secured to the pipe ends and bolted together as shown in Figure 56. A gasket is placed between the meeting faces of flanges in order to make a tighter connection.

In hydraulic installations, flanges are either screwed to the threaded end of the pipe and backwelded, as in the cross section view of Figure 57; or they are slipped over the end of the pipe, welded front and back, and then refaced flush with the pipe end (Figure 58). The welding eliminates any possibility of leakage between the flange and the pipe.

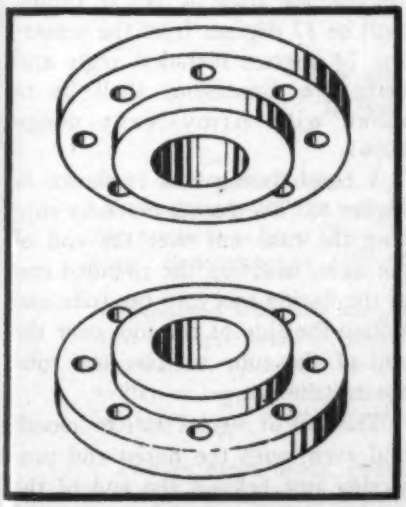


Fig. 55. Typical plain raised flanges used on high pressure and large diameter lines.

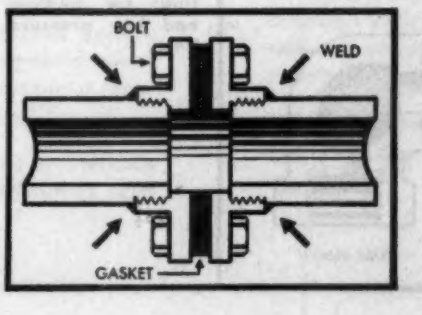


Fig. 56. The simplest type of flanged connection with gasket between meeting faces and back welding.

Types of flange face. The joining surfaces of flanges can be faced in many ways to secure a tight joint. Figure 59 shows three of the most common types of faces used in hydraulic installations.

Flanges with plain raised faces have a machine ground surface and may be used with either a square or ring gasket. With this type of joint the flanges must meet perfectly. Yet the plain raised face type has several advantages over other types, in that all mating of flanges is eliminated, the gasket is easy to center and a section of piping fitted with this kind of flange can easily be removed without springing the line apart.

The male and female type of flange face has a cut away (female)

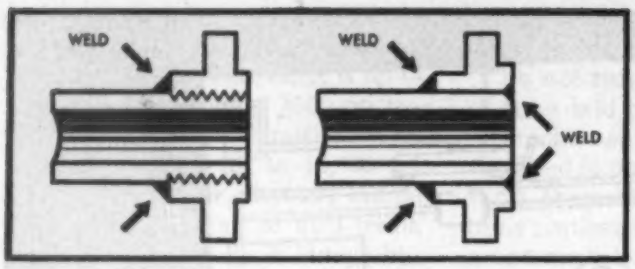


Fig. 57 (left and Fig. 58 (right) show screwed and back welded flanges and slip on and welded front and back flange types respectively.

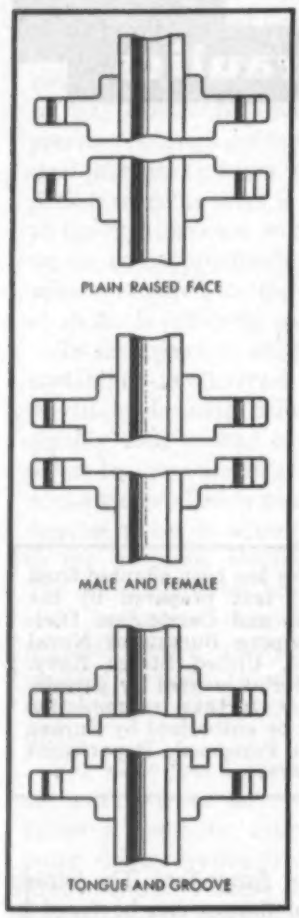


Fig. 59. Three of the most common types of flange faces used in hydraulic installations.

area on the face of one flange and a corresponding raised (male) area on the face of its mate. It normally takes a small ring gasket. This makes a more secure joint than the plain raised face type. The tongue and groove type of face has a raised ring on one flange and a corresponding ringed groove or cut away area on the other flange.

Flanges that must be mated are undesirable from the maintenance standpoint, since interconnected units have to be sprung apart in order to remove from the line. They are used, however, in high pressure installations, where the plain raised face type does not make a satisfactory connection.

Flanged joints are usually bolted securely together by four bolts. The flanges must line up squarely. When being assembled, bolts diametrically opposite should be set up fairly tight. Then the other two bolts should be set up an equal amount. The bolts should then be taken in order, setting up each one an equal amount, until on the last round they are equally tight.

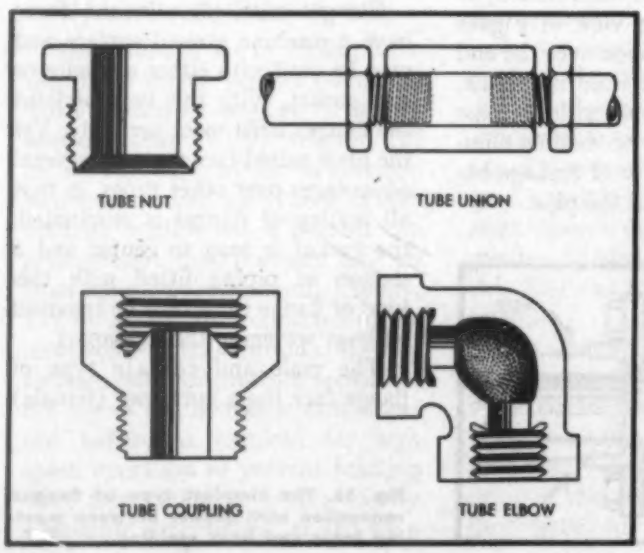


Fig. 60. Typical compression fittings for medium and low pressure lines.

The flanged fittings used on hydraulic tubing are identical with flanged pipe fittings. They are used on high pressure tube lines.

Compression Fittings

Compression fittings are used in medium or low pressure tube lines and are of many kinds. Some of those most commonly used are shown in Figure 60.

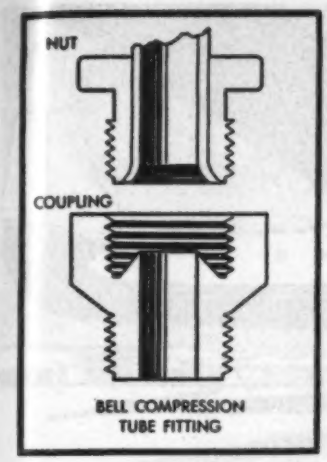
The Bell type compression fitting consists of a tube nut and a tube coupling so threaded that the coupling will screw down over the nut. The nut is fitted over the tube, and the end of the tube is then flared. The nut and the flared tube end are then fitted into the female opening of the tube coupling (Figure 61). As the tube nut is tightened, the flared end of the tube is compressed against a machined taper in the tube coupling, providing a firm connection.

The Parker triple compression fitting is very similar, except that a sleeve is placed between the flared tube and the nut, as shown in Figure 62. The sleeve protects the flare from strain as the nut is tightened, since the nut turns against the shoulder of the sleeve instead of directly against the flare.

Flaring. In order to obtain a firm compression connection the end of the tube must be flared properly. Until recently there has been no general agreement among manufacturers on the degree or angle of flare of tubing. However, the J.I.C. Hydraulic Standards for Industrial Equipment (section H4.1.6) specifies that the angle of flare of tubing shall be 37 degrees from the centerline 74 degrees included angle and that flare dimensions shall be in accord with Army-Navy design 10061.

A hand flaring tool is shown in Figure 63. The flare is made by slipping the tube nut over the end of the tube, inserting the rounded end of the flaring tool into the tube and rolling the side of the tool over the end of the tube to flare the tube against the nut.

The seat of a good flare is smooth and even, with the flared end projecting just beyond the end of the tube nut. The maximum diameter of the flare should be slightly less than the nose of the tube nut. In Figure



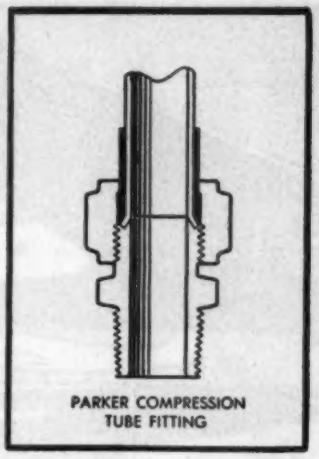
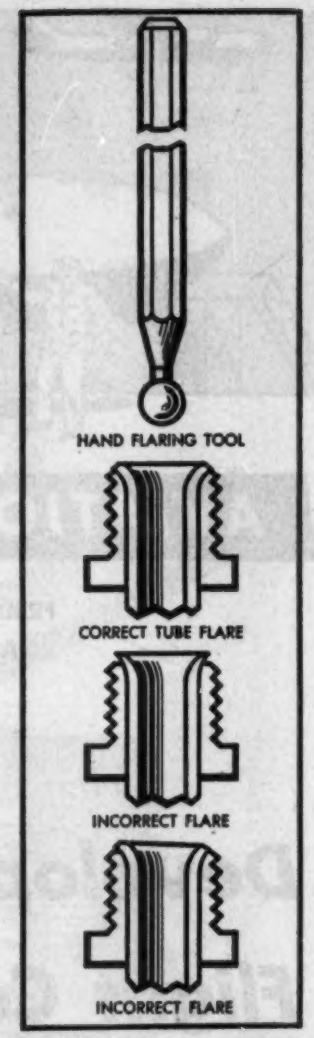


Fig. 61. In this type fitting (left), the nut is fitted over the tube which is then flared, the nut and tube fitted into the coupling and the nut tightened, sealing the flared end against the taper in the coupling.

Fig. 62. This type (right) employs a sleeve between the flared tube and nut to protect the flare from strain as the nut is tightened.

Fig. 63. A hand flaring tool and examples of correct and incorrect flares.



63, a good flare is shown, along with two badly made flares.

When the tube is properly flared and the tube nut is tightened, the flare will seat itself firmly in the machined recess of the tube coupling. The tube will not turn relative to the coupling when the nut is tightened, and the flare will assume the shape of the machined recess. Any irregularities in the machined recess will be taken up by the tube flare, making a leak-proof connection.

If the original connection is broken, however, and the compression tube fitting must be reassembled, it is very improbable that the flare will contact the machined recess in the original places. It is therefore necessary to anneal or soften the flared end of the tube prior to reassembly.

Copper can be annealed by heating it to a red heat and then quickly quenching it in cold water. This process will soften the copper enough to allow it to assume the shape of the coupling surface when the tube nut is tightened. Only copper tubing is to be annealed. When compression fittings are used with steel tubing, a thin copper gasket is placed as a seal between the tube flare and the machine recess. This copper gasket must then be softened before reuse.

Hydrostatic test before using. All piping, tubing and fittings used in hydraulic systems must be subjected to a hydrostatic or static pressure test before being put to use. The system is filled with water and subjected to a test pressure of approximately 50 percent more than the maximum planned working pressure for each part. In this way a system free from leaks and possible breaks will be assured.

The next installment of these lessons will cover a procedure for the maintenance of hydraulic equipment. This will conclude chapter four and the questions for this chapter will also be published as usual. Be sure to preserve each installment for future reference.

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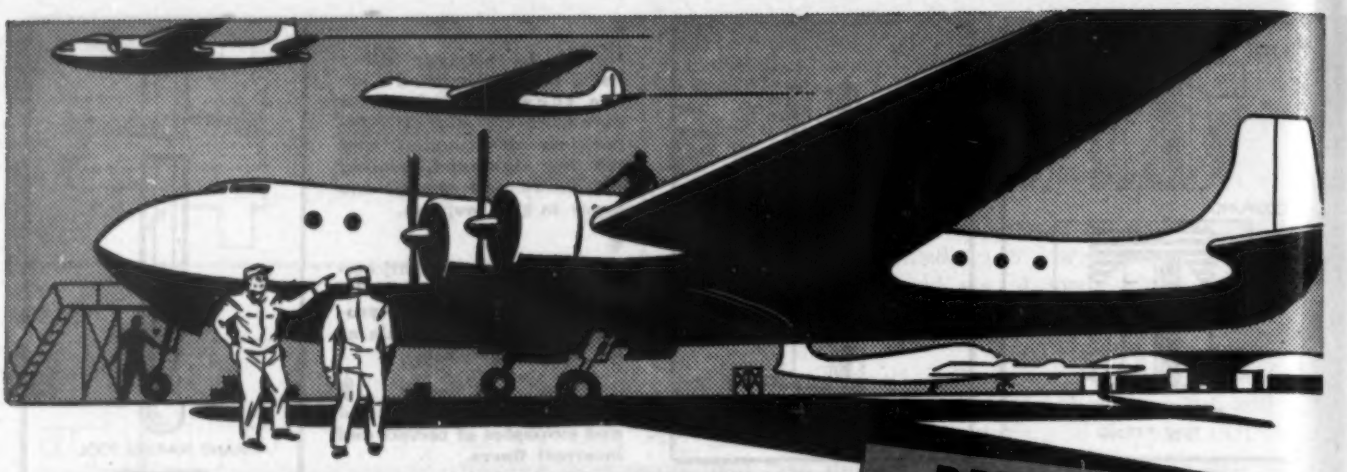

AVIATION HYDRAULICS

DESIGN
OPERATION
MAINTENANCE

FRED O. HOSTERMAN
Advisory Editor

Development of the Constellation Flight Control Booster System

By ROBERT R. RICHOLT
Mechanical and Hydraulics Staff Engineer, Lockheed Aircraft Corporation, Burbank, California

Introduction

FEW PERSONS NOT DIRECTLY CONnected with the development problems of a new airplane realize the tremendous job involved in the designing, testing, and building of a new type of aircraft. The larger the airplane and the more new equipment used therein the more difficult are the problems involved. This discussion is a brief history of the development of just one system on the Lockheed Constellation—the flight control booster system.

At the time the Constellation was conceived, little use had been made of flight control booster systems on previous aircraft. Several systems had been designed and tested by other companies, however, none of these had been used for extended periods of time and under a wide variety of climatic conditions. For all practical purposes, the field was new and it was felt that a completely new development was required in order to arrive at the most satisfactory solution to the problem.

This article was specially prepared from and is an extract of the paper, "Development of the Constellation Hydraulic System" by Mr. Richolt, delivered at the National Conference on Industrial Hydraulics on October 27 at the Sheraton Hotel, Chicago.

The Problem Statement

The initial design studies for this airplane were undertaken in June of 1939. It was conceived as a long range, high speed, high altitude transport, with low operating cost as a basic requirement. The flight characteristics were to be a substantial improvement over those of existing aircraft, with maximum controllability for all emergency and normal flight conditions. New Civil Air Regulations required a low landing speed to permit the use of small emergency fields. The paramount requirement was safety in combination with speed and economy.

The safety and economy requirement indicated the use of four of the largest engines then available to obtain the lowest fuel consumption during cruise conditions. These large engines also permitted the best take-off performance but posed a serious problem in maintaining complete directional control during take-off should an engine fail. The turning

(Continued on page 22)

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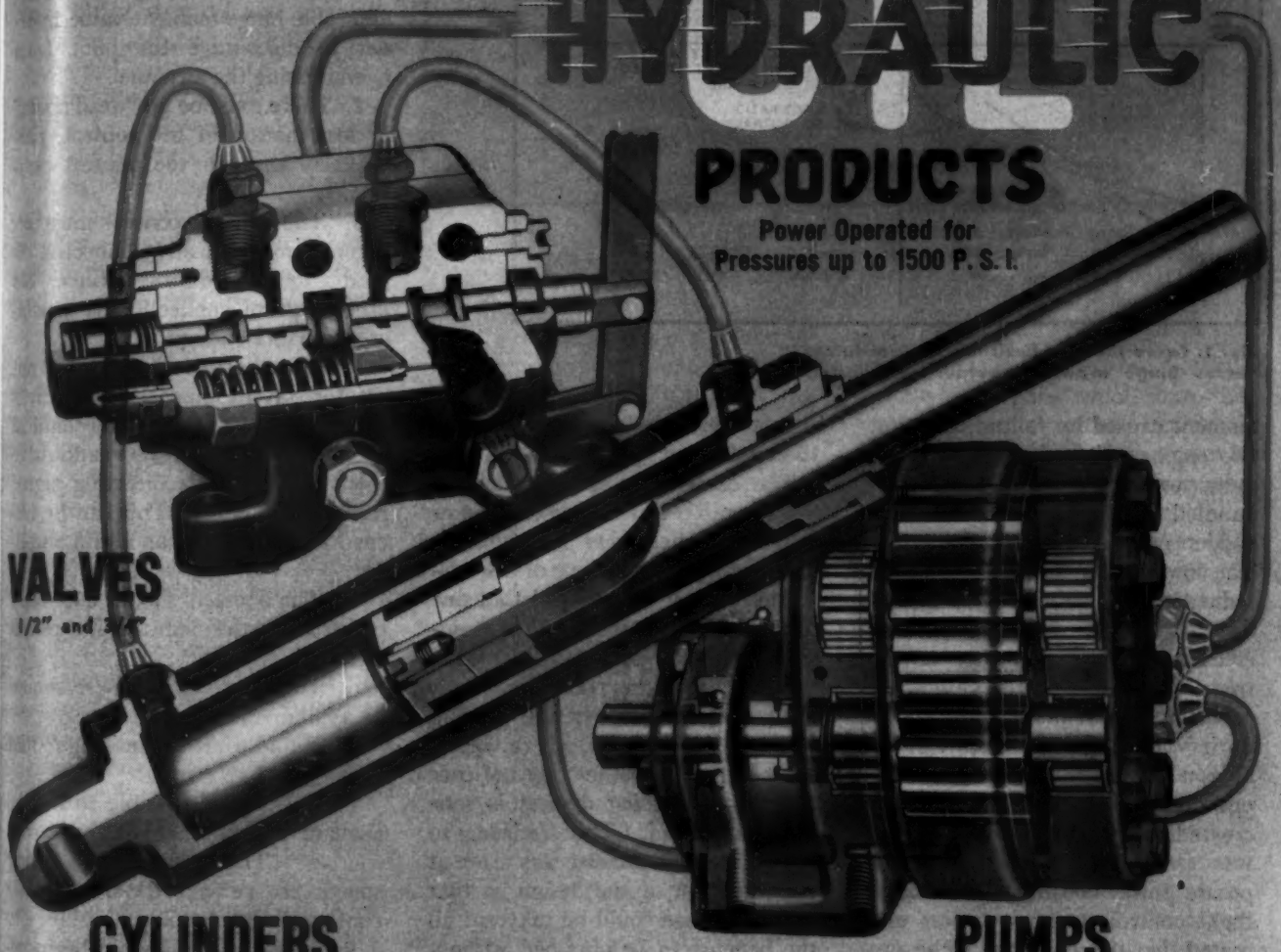

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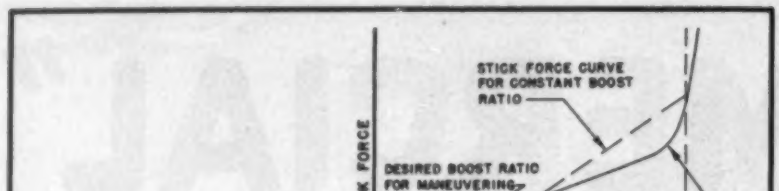

STICK FORCE CURVE FOR CONSTANT BOOST RATIO
STICK FORCE
DESIRED BOOST RATIO FOR MANEUVERING
MAX. MOMENT LIMITED BY DESIGN OF BOOSTER
CONTROL SURFACE ANGLE OR HINGE MOMENT APPLIED TO THE SURFACE
LOW BOOST RATIO AROUND NEUTRAL
DESIRABLE TYPE OF STICK FORCE CURVE

Fig. 1. Curve showing desirable control forces versus hinge moment output of booster.

moment caused by failure of one or two engines when developing maximum power was more than could be handled by the normal methods of rudder control used at that time. The low landing speed requirement indicated the use of a large Fowler flap to give the wing a high lift coefficient. By incorporating an extremely large flap in the design, the problems of ample elevator control during landing and satisfactory aileron control with two engines on one side inoperative were greatly increased. The basic design, therefore, was tentatively planned to incorporate power boosters on all of the flight control surfaces. It was estimated that the assistance to be supplied by these boosters, or the amplification of the forces applied to the controls by the pilot, would require ratios of 30:1 for the rudder control, 10:1 for the elevator and 8:1 for the ailerons. Control surface angular velocities should be at least 40 degrees per second.

The decision to use boosters on this aircraft was based upon a number of practical and aerodynamic reasons beyond the scope of this discussion, but it can be said that one of the main reasons was the increased safety obtained by using boosters, since they permitted complete control down to the stalling speed of the airplane, where the effectiveness of all other types of control force reducing devices is seriously impaired. The decision to proceed on this premise was made at the inception of the design so that full advantage could be taken of all the benefits to be obtained without compromise.

The only problem was how to build such a device for each of the three controls which would meet the following requirements:

1. Give the type of stick force curve shown in Fig. 1, where the effective ratio between input and output (the boost ratio) was relatively low near the neutral position to obtain good stick free stability of the airplane, would increase to the desired value for higher loads to be expected during maneuvers, and would decrease near the maximum allowable hinge moment value in order to discourage the pilot from overstressing the airplane.

2. There must be no "dead spots" or lost motion of the control, particularly through the neutral position.

3. The cockpit control must *always* be mechanically connected directly to the control surface. No other type of connection is considered reliable enough.

4. The booster system must not "motor". With improper design it is possible for any type of mechanical servo unit to act in reverse and drive the load without a directing signal from the input end. This can be likened to feedback in an audio amplifier.

5. The boosters should take their power from the main engine power plants.

6. Dual sources of power should be available automatically.

7. Rapid shut-off means should be provided.

8. It must be possible to fly the airplane after failure of the power sources. (This means higher air speeds are required for adequate control during landing.)

9. Relief valves should be incorporated to limit the maximum control surface loads to their design values.

10. Control surface trim tab effectiveness must not be lost due to booster friction.

Fig. 2. Diagram of original rudder booster. This system built for test in the laboratory proved unsatisfactory due to violent oscillation and poor reversibility.

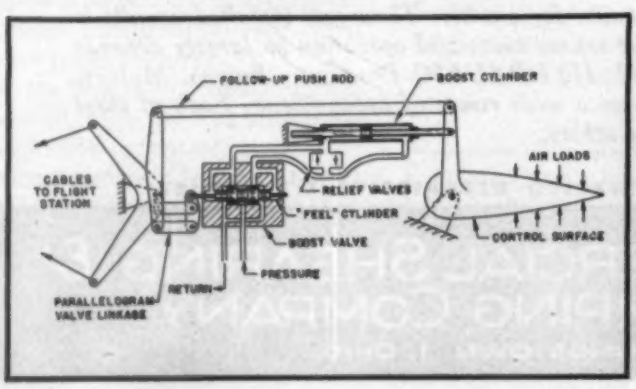
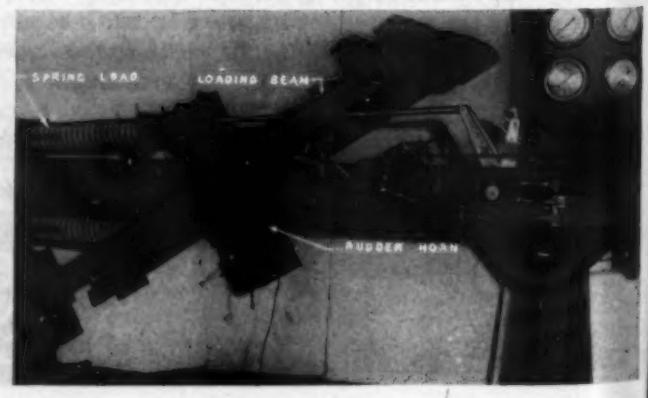


Fig. 3. Original rudder booster in its laboratory test jig.



11. The booster must be capable of operation at very low temperatures.

Design

With the above set of requirements, Lockheed engineers started the design work in the summer of 1939. After a study of the power requirements it soon became evident that hydraulic power was the only feasible method of doing the job, especially in view of the high momentary demand placed on the system by the boosters. After providing a system which would meet the boost requirements there was a surplus of power available which could be used for all the remaining hydraulically actuated services, providing it was so arranged that the boosters had first priority.

A nominal 1500 psi system was selected as the best compromise at that time since little was known about equipment for higher pressures. In fact, up to that time all of our experience had been with relatively simple systems operating in the 600 to 1000 psi range. The higher pressure was justified on the basis of weight saving. Even so it would require the development of new pumps to do the job. Another innovation for that time was the decision to use automatically variable volume pumps since the boosters would require power continuously and it was expected that the pounding given a system by a regulator would not be conducive to long life. This decision later proved to be correct although development of the new pumps certainly was no easy task.

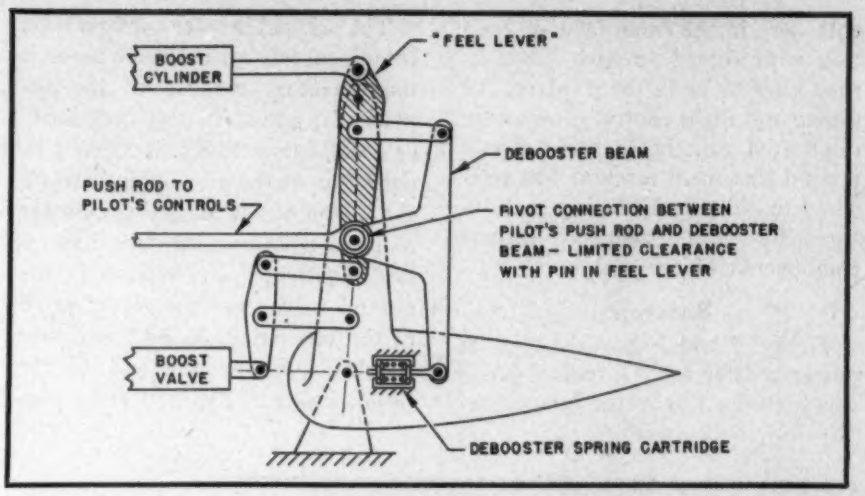

BOOST CYLINDER
"FEEL LEVER"
DEBOOSTER BEAM
PUSH ROD TO PILOT'S CONTROLS
PIVOT CONNECTION BETWEEN PILOT'S PUSH ROD AND DEBOOSTER BEAM – LIMITED CLEARANCE WITH PIN IN FEEL LEVER
BOOST VALVE
DEBOOSTER SPRING CARTRIDGE

Fig. 4. Diagram of the revised rudder booster showing the "feel" lever which eliminated and replaced the "feel" cylinders.

To meet requirements 5 and 6 above, a pump was mounted on each of the four engines, with the two left-hand pumps supplying the power for boosters only, and the two right-hand pumps supplying power for the other services. These were known, respectively, as the primary and secondary systems. In addition, automatic switch-over provisions were made so that in case of failure of the primary pumps the secondary system would supply power to the boosters. To meet the priority requirements a restriction control valve was to be located in the secondary supply line downstream from the switch-over valve.

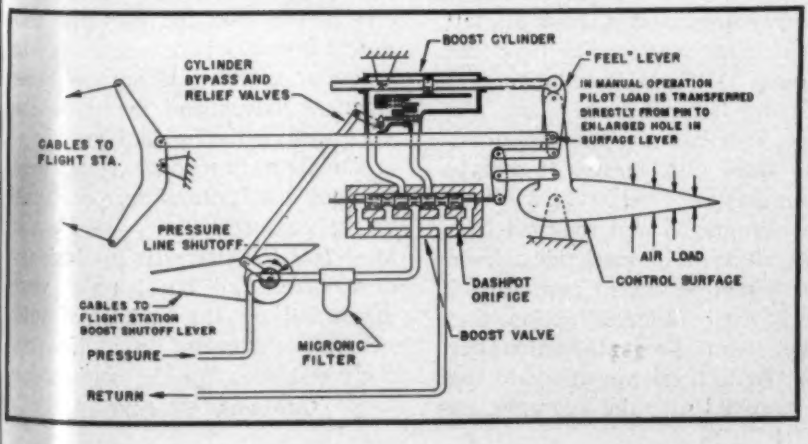
Mockup

It was evident from an examination of the problem that development of such a complex system on the airplane would cause too much delay. The effect of one part of the system upon another had to be thoroughly investigated, and since the whole airplane's success depended upon the boost controls it was evident that considerable laboratory testing and development would be necessary before it would be safe to anticipate satisfactory operation on the airplane itself. In many cases there were several choices of details in design, and the only way to determine the best choice was through test. It was decided that a hydraulic mock-up simulating the airplane in all possible detail would be the only feasible method of obtaining answers to the many questions.

In order to handle this program expeditiously, a mechanical research group was established as a separate group in the engineering department. The size of the airplane immediately determined the physical requirements of the test area. The requirement of a clear floor space approximately 100 x 100 feet with a ceiling height of 16 feet resulted in the erection of a two story research laboratory. The major portion of the upper floor housed the hydraulic mockup and the lower floor contained the machine shop. In a project of this nature it was found essential to maintain extremely close cooperation between the engineers and the shop.

The mockup was located on a platform above the laboratory floor to permit installation of the landing gear mechanisms in proper relationship to the rest of the hydraulic system. Flight station, control surface boosters and all other compon-

Fig. 5. Detail of the rudder "debooster" linkage which permitted the booster to work at a 2:1 boost ratio at low hinge moment or stick force conditions and corrected the hunting characteristics of the original design.



ents were in the same relative position with regard to each other as they were to be in the airplane. All piping and flight control cables were duplicated exactly to scale. Space around this main mockup was relegated to individual test jigs and fixtures for development of various components of the system.

Boosters

Figures 2 and 3 show the original power booster for the rudder which was built for test in the laboratory.

The original booster configuration contained deficiencies which made it unsatisfactory for use on the airplane. In actual tests it "motored" or oscillated violently. Resiliency or deflection of the oil column between the piston of the actuating cylinder and the piston of the "feel" cylinder, aggravated by friction in the control valve, was the major cause of the oscillation. In addition, lead weights hung on the end of the beam shown in Fig. 3, for the purpose of loading the mechanism, inadvertently provided the "flywheel" and the net result was a hydraulic engine. Reversibility of this type of booster is very poor due to the accumulative effects of friction in the actuating cylinder and control valve.

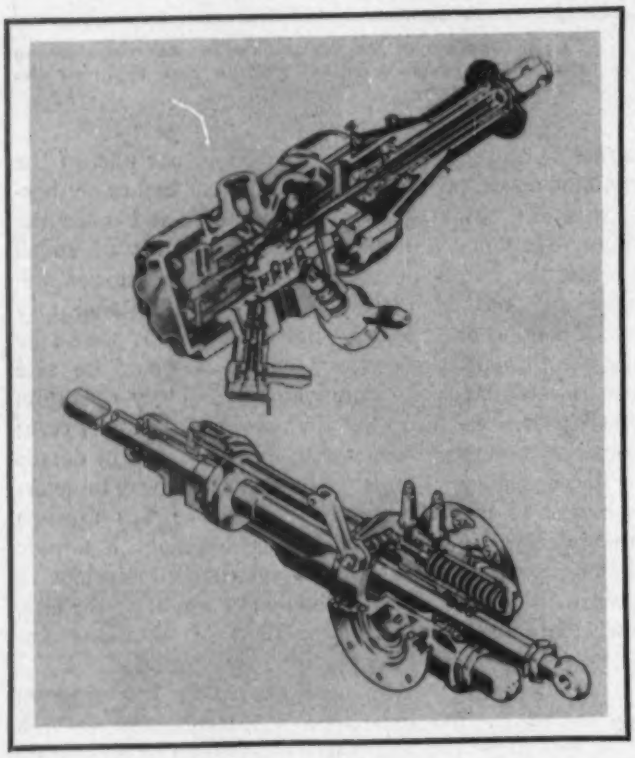


Fig. 6. The final configuration of rudder boost valve (top) and actuating cylinder. Similar units were used as elevator and aileron boost units.

The control valve is mounted to fixed structure and controlled by a parallelogram linkage which provided follow-up and directional sensing. The actuating cylinder connections were made through swing joints located on the axis of the mounting trunnions for the cylinder. This permitted the elimination of flexible lines which were considered a hazard. The booster valve is balanced and opens the pressure and return ports simultaneously. Incorporated in each end of the valve is a "feel" cylinder connected directly to the actuating cylinder line. The area of this "feel" cylinder as compared to the area of the actuating cylinder determined the boost ratio or amount of "feel" received by the pilot from a load on the control surface.

This type of booster mechanism has since been used on other aircraft but at lower boost ratios than that required by the Constellation.

Figure 4 shows the revisions necessary to obtain acceptable performance from the booster. It will be noted that the "feel" cylinders have been eliminated and replaced by a "feel" lever. The mechanical leverage system permitted accurate follow-up with minimum friction, since it was mounted on anti-friction bearings. Deflections equivalent to that encountered with the hydraulic leverage system were reduced to a minimum. In the revised booster it is not necessary to move the power cylinder piston rod before the valve is actuated, since the power cylinder piston will only move as directed by the booster valve. The "feel" lever actually pivots about the piston rod connection until the boost valve has been actuated far enough to direct fluid to the cylinder and cause it to follow. The valve has been redesigned for minimum friction and incorporates dashpots in each end to limit the velocity of movement of the valve shaft. The orifices in these dashpots are adjusted so as to limit the valve actuation speed to a point well below the natural "motoring" or oscillation frequency of the mechanism. With a hydraulic follow-up system such as used in the first booster, the amount of damping required is relatively large, but with the lever system used the natural frequency of the mechanism is high enough to require relatively little damping. The actual amount of damping required for stability in a booster of this type is a function of the boost ratio, the inertia on the output end of the mechanism (the surface), cylinder thrust, friction in the linkage and packings, spring rate of the control system between booster and flight station and spring rate of the system between booster and the control surface.

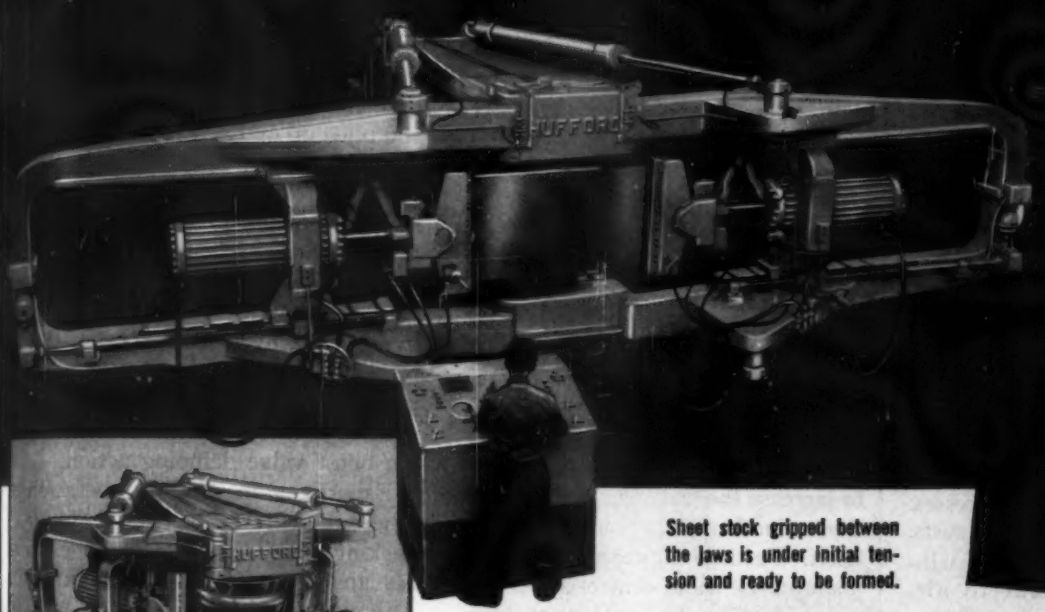
In case of hydraulic system failure, the shut-off valve in the pressure line is actuated simultaneously with operation of the by-pass on the cylinder to shut off the booster. The pilots' controls then are connected directly to the surface, with a small amount of lost motion due to the valve linkage.

This booster configuration produced what was thought to be satisfactory performance for incorporation in the mockup. Elevator and aileron boosters were constructed in a similar manner, using the same identical valves and many of the same parts as the rudder booster.

Complete functional tests were conducted at normal temperatures, in the cold room at —65 F, and at +160 F. After the preliminary development all boost units were mounted on the main hydraulic mockup and cycled in a life test. This test was run in conjunction

(Continued on page 26)

HUFFORD HYDRAULIC STRETCH-FORMING MACHINES



Sheet stock gripped between the jaws is under initial tension and ready to be formed.

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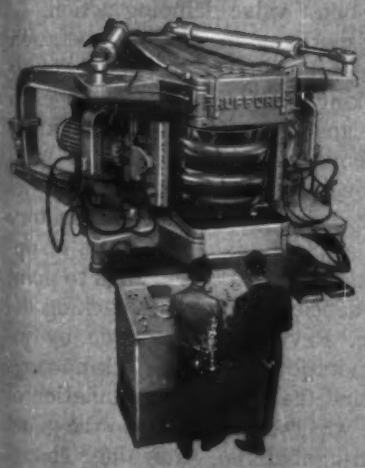

Upon completion of forming operation, sheet is stretched to "set" material to die contour.

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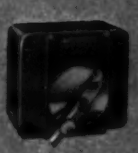

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(Continued from page 24)

Again, changes were found necessary. Life cycling disclosed weaknesses in linkage parts and piping details. After correcting these difficulties the mockup was put through a regular flight schedule simulating take-off, climb, cruise, approach and landing for a period of 200 hours.

The first flights were successful and, in fact, the airplane set a new record in making six flights the first day. Although the first flights were considered very satisfactory, it soon became evident that considerable improvement was still necessary to obtain good performance and reliability.

The first revision concerned the booster valve. It was determined from flight tests that metering characteristics of the valve needed improvement to obtain smooth operation. Better results were obtained by revision of the slide valve clearance to increase the leakage rate, and further reduction of friction in the valve itself. Further improvements were made in the cable control system to reduce friction. These minor changes improved the stability of the airplane, but were not enough to eliminate oscillation or directional hunting of the airplane in certain cruise conditions. We had exhausted most of the possibilities for improvement while still retaining the original hydraulic boost ratio, and it was evident that to obtain still further impovement, the boost ratio in the "hands off" or stick free condition must be reduced on both the rudder and elevator boosters. This was done by the "debooster" linkage shown in Fig. 5. This linkage permitted the booster to work at a 2:1 boost ratio at low hinge moment or stick force conditions. After the pilot increased his load to a predetermined value the clearance between the pin on the "feel" lever and the hole in the pilot's push rod is taken up, and the boost ratio is effectively increased to the original high value. In the "hands off" cruise condition this permitted the control surface to adjust itself easily by overcoming the cable control system friction at a 2:1 (disadvantage) ratio instead of the 30:1. This revision corrected the hunting characteristics on the airplane and provided the steep slope around neutral indicated on the curve of Fig. 1.

Further experience indicated that possibility of hazard existed in the booster valves should the orifices in the dashpots become plugged. In fact, one of these orifices became plugged with lint, in ground test operations. In order to eliminate this hazard, screens were located on either side of the orifices. Then it was discovered in laboratory testing that these screens could be stopped up at low temperatures should the hydraulic fluid contain over 5 per cent water. The water crystals froze and piled up on the screens, so relief valves were added. These relief valves were set to crack at a pressure low enough to permit the pilot to override a plugged orifice but high enough so as not to interfere with the damping action of the dashpots in the valve. Inadvertently, this produced another advantage. It permitted the pilot to move the control suddenly, if so desired, overriding the boost valve damping action.

Experience in air line operation required revision to the cylinder packing design as well as changes in fits and clearances of the linkage. Although all boosters had gone through a 200,000 cycle life test before being considered satisfactory for airplane usage, 50 hours of operation in flight was enough to point up deficiencies in gland packing design. Revisions were made by incorporation of leather back-up rings behind the "O" rings, installation of felt wipers and revision to the gland bearing material. After these changes, cycling tests were run through one half million. Service experience indicates that this has produced a satisfactory design.

The final configuration of boost valve and cylinder is shown in Fig. 6. The relief valves built into one end of the cylinder limit the pressure which can be built up across the piston, and in this way limit the hinge moment which can be applied to the surface .This produces the sharp upturn in the curve of Fig. 1 near the extremes. Although simple in its principle of operation, the boost valve is complicated in construction due to the requirements of friction reduction. This is the reason for the ball universal joints to permit alignment and eliminate bind due to machining tolerances. These valves must operate with a maximum of one pound force on the shaft.

Elevator and aileron boost units

are constructed similar in principle to the rudder booster and many of the same parts are used.

Concurrently with development of the booster units, the hydraulic system was being developed, and it was found that even with a primary and secondary system as mentioned above there still existed the possibility of failure of a common line supplying the rudder and elevator boost units in the tail of the ship. Should this failure occur during take-off or landing it could cause loss of boost at a time when it was most needed. In order to provide a safeguard against this contingency, it was decided to add a small auxiliary power system at the elevator and rudder boosters to be used only as a standby for these conditions. This consisted of an electric driven gear pump, accumulator, pressure regulator and a sump tank through which the main return flow passed, insuring that the auxiliary system was always charged with oil. Relatively little trouble developed with the auxiliary boost systems and both systems have remained essentially unchanged.

Seeing Is Believing!

The Bellows Company has just released a 16 mm black-and-white sound motion picture, "Production Miracles Through 'Controlled-Air-Power'." The 28 minute film, over a year in the making, shows actual production scenes in a number of modern plants, large and small, showing in detail how the applications of "Controlled-Air-Power" devices to standard and custom built machine tools cut costs, increased production and reduced fatigue in such operations as milling, drilling, tapping, grinding, etc.

A new 30 minute sound film produced by The Denison Engineering Company, showing close-up views of their Multipress in action in production, testing and research work, is now available for booking. The range of operations includes broaching, trimming, forming, marking, crimping, assembling, staking and many others. The tooling setups shown in this film are alone assurance of a well spent half hour.

Either of these films may be booked by writing either company or by contacting the respective sales representative in your area.

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New PRODUCTS

For additional information on any of these products, mark the end key numbers on the card bound in this issue and mail the card.

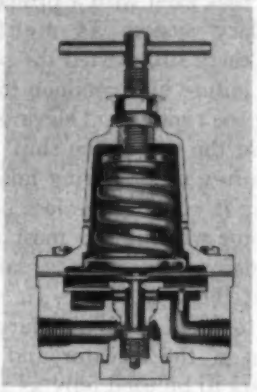
Automatic Reversing Vane Pumps

A new series of automatic reversing vane pumps, just announced by Brown & Sharpe Mfg. Co., represent an important addition to this company's expanding line of pumps. The new pumps offer

outstanding advantages to users who require automatic reversing pumps which maintain unidirectional delivery regardless of direction of shaft rotation on machines and mechanisms which reverse. The pumping action is provided by a rotor containing four sliding vanes held by springs and hydraulic pressure against the internal surface of an eccentric. The vanes alternately create suction and pressure as the rotor turns. Three sizes Nos. 8021, 8061 and 8101 have rated capacities of .6 to 2.5, 1.4 to 5.2 and 2.9 to 11.5 gpm at 0 psi; all are designed for continuous pressures up to 100 psi. Pumps are available complete, as stripped models with housings or as stripped models without housings to cover a wide range of installation requirements. *1.*

Pressure Regulators

The Series 2AX pressure regulators with built-in relief valve are now available from C. A. Norgren Co. in six sizes from ⅛ in to 1 in. Designed for primary pressures to 400 psi and secondary pressures to 250 psi, the model 2AX regulator incorporates a baffle plate and syphon tube which provides greater air capacity. The tube opening is sized to give instantaneous reaction to flow requirements and provide protection against chatter as well as guard the diaphragm against shocks caused by surges in secondary pressures. The simple, efficient design of the relief valve assures



positive, trouble-free action for uniform and close pressure regulation. *2.*

Adjustable Stroke Air Cylinder

A new adjustable stroke air cylinder announced by Anker-Holth Manufacturing Co. permits the use of full stroke or any part of the stroke. A false piston forming the movable blind end is attached to an adjusting screw, the movement of which gives any desired length of stroke. The false piston maintains an air tight seal, limiting the dead air space. Air is passed through a swivel

(Continued on page 30)

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(Continued from page 28)

connection attached to the adjusting screw to feed the piston on the "out"

stroke, a hand wheel locks the adjustable screw in any position. Cylinders are manufactured in bore from 3 to 14 in. *3.*

All-Purpose Coolant Base

Safco No. 770 Compound, a new water-soluble coolant base that offers definite economies in coolant and machining costs, is announced by Swan-Finch Oil Corporation. The compound, with the consistency of a liquid paste, combines all of the essential qualities of a grinding compound and a sulphurized cutting oil, without their objectionable features. When used in grinding operations in a water mixture as high as 80 to 1 it will prevent wheel-loading, reduce wheel dressings, keep work from rusting and keep solutions free of foul odors. In machining operations, Safco 770 solutions exhibit the lubricating and anti-weld properties of sulphurized oils. *4.*

Small Helicoid Gage

Helicoid Gage Division, American Chain & Cable Co., Inc., has just added a new 3½ in dial to its gage line. Made

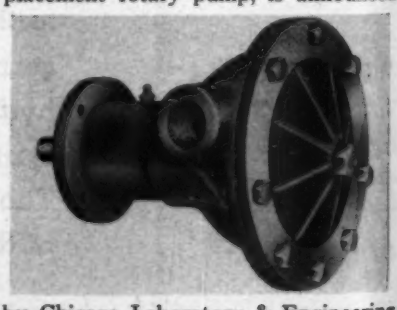
with a steel Bourdon tube and with the same features of the larger Helicoid gages; no teeth to wear out; stainless steel bearings, Korex steel Bourdon tubes; fused joints; and external pointer adjuster, the new gage is particularly adaptable to pumps, compressors and hydraulic press applications. In addition to the new 3½ in size, the Helicoid gage is also available in 4½, 6 and 8½ in dial sizes. *5.*

Snap-Action Gate Valve

A new snap-action, pressure operated, solenoid controlled, gate valve is announced by Hydro-Aire, Incorporated. Designed for use with practically any type liquid, the new No. 3308 valve has opening time adjustable from ¼ to 5 sec, closing time less than 1/10 sec for a 1½ in opening. A latching type solenoid is incorporated, in case of power failure the valve will remain in its last energized position. A non-latching type solenoid can be furnished to operate the valve as a fail safe unit. The valve is designed for high pressure and for a wide range of temperature applications. *6.*

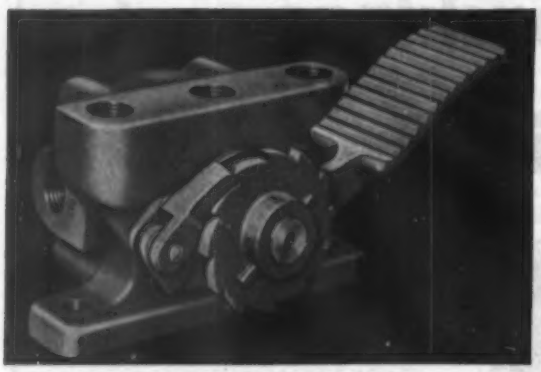
Controlled Floating Vane Pump

A new pump, embodying controlled floating vane principle in a positive displacement rotary pump, is announced



by Chicago Laboratory & Engineering Co. The company reports that liquids, gases and air have been pumped and that the pump can be used as a fluid motor with high starting torque and a wide speed range. Radial control is achieved through an exclusive yoke-

NEW Foot Valves by NOPAK



NOPAK Model "F" Foot Valve

NOPAK Model "R" Foot Valve

These new Model "F" and Model "R" Foot Valves embody a number of installation and operating advantages which include:

- **Eliminating the internal exhaust core in the valve disc.**
- **Larger *effective* exhaust area . . . increases valve capacity.**
- **Reduced possibility of plugged passages.**
- **"Exhaust" port located at top of valve, between the two "cylinder" ports, simplifies piping.**
- **Reduced overall height.**
- **Compact streamlined appearance, more eye-appeal.**

Designed primarily for air service, both valves may be adapted to oil or water hydraulic service, for pressures up to 100 P.S.I., at slight extra cost.

GALLAND-HENNING MFG. CO., 2743 S. 31st Street, Milwaukee 15, Wis

WRITE FOR NOPAK FOOT VALVE BULLETIN

●

Representatives in Principal Cities

NOPAK
VALVES AND CYLINDERS
DESIGNED for AIR and HYDRAULIC SERVICE

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Room 258
Park Square Bldg.
Boston 16, Mass.

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205 E. 42nd St.
New York 17, New York

J. D. HARSHAW
202 Highland Ave., Lansdowne
Philadelphia, Pa.

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Pittsburgh 12, Pa.

BRENNER INDUSTRIAL SALES
3931 Market St.
Youngstown 5, Ohio

PURCELL BROS.
3344 Erie Ave.
Cincinnati 8, Ohio

GARRETT BURGESS, INC.
5050 Joy Rd.
Detroit 4, Michigan

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JOHN HENRY FOSTER
1014 Second Ave., South
Minneapolis 4, Minn.

2850 Gravois Ave.
St. Louis 18, Mo.

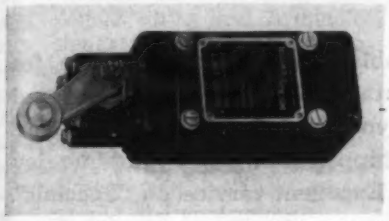
BOWERS HOIST & WINCH
10810 S. Alameda St., Lynwood
Los Angeles, Calif.

TRANSMISSION ENGINEERING
53 Stevenson St.
San Francisco 5, Calif.

cross head and off center pin, lateral control by locking the vanes inside of the rotor, eliminating all end thrust movement. Radial and lateral control "floats" the vane ends in the working chambers, preventing them from touching the sides or race. Three models for handling 10 to 25 gpm at continuous operating pressures of 50 to 70 psi are available. *7.*

Precision Limit Switch

A new Micro-Limit precision limit switch is announced by Micro Switch. The new switch, designed for use on all types of machinery and industrial equipment, combines precision operation with adjustability features and extreme ruggedness. The operating head



may be adjusted to any of four horizontal positions; the roller arm assembly may be reversed to position the actuator roller on either side of the actuator arm. The switch is field adjustable to operate clockwise, counterclockwise, or in both directions. The actuator arm assembly, adjustable through 360 degrees, can be locked at any of 870 positions. *8.*

CIRCLE NUMBERS ON THE CARD AND MAIL!

Clamp Meter

A new ac clamp ammeter and voltmeter, Model 633 Type VA-1, for measuring alternating currents and voltages without interrupting electrical service, has been announced by the Weston Electrical Instrument Corporation. The meter, with five current ranges up to 1000 amperes and three voltage ranges up to 700 volts, will accommodate conductors, bare or insulated, up to two inches in diameter. Current and voltage measurements can be made almost simultaneously by rotating the thumb-selector switch. A pointer stop has been provided to show motor-starting currents. *9.*

Controlled Humidity Method

A new system of controlling temperature and relative humidity to hold constant conditions or to vary them at the will of the user is announced by the Niagara Blower Co. The "Controlled Humidity Method" uses an absorbent dehumidifier, "Hygrol", a hygienic hygroscopic chemical that absorbs air-borne moisture and contains no salts or solids to precipitate. Dry atmospheres at normal working temperatures with little or no refrigeration required are achieved; a condition of 15 grains of moisture per

—of quality and precision as demonstrated by Mr. G. R. O'Ring

Dimensionally exact . . Uniform . . Blemish-free . .

- GRC "O" rings, meeting rigid inspection standards, assure positive, long-life sealing under severe high-pressure static and reciprocating applications.
- With accuracy paramount, GRC "O" rings are equally effective in sealing delicate, very low pressure mechanisms where tolerance and friction factors are most critical.

Lab-Controlled Specification Compounds . .

- Constant laboratory tests insure consistent material content for all "O" ring compounds, both general and specific-purpose.
- Minimum-variation materials contribute to the certainty that superior results will be provided by each and every GRC "O" ring.

Selection of GRC "O" rings, both as original and replacement seals, will reflect in increased high-level performance and reliability for your product.

There is a free copy of "O" Ring Catalog "C" we would like to send to you. "G. R." just needs the word from you and he'll rush it out.

Manufacturing quality mechanical rubber goods for 33 years

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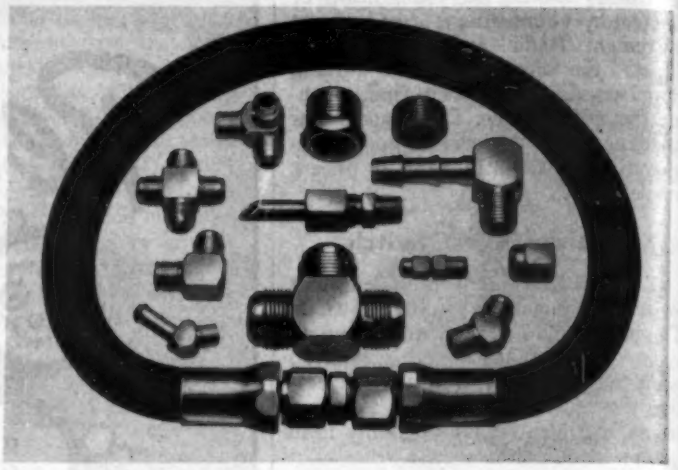
WHEN YOU CHANGE TO

J.I.C. Standards

LET L&L SERVE YOUR HYDRAULIC PIPING NEEDS



- **STEEL TUBE COUPLINGS**
  for ⅛th to 2 inch O.D. tubing
  2 PIECE TITE-SEAL FOR ECONOMY
  3 PIECE LOCK-JOINT-SLEEVE TYPE
- **HOSE ASSEMBLIES**
  with pressed-on couplings for single and double wire braid hose
- **PIPE FITTINGS**
  Straights, Ells and Tees with "Dryseal" pipe threads (N.P.T.F.)
- **PRE-FABRICATED TUBES**
  Let us estimate your preformed tube assembly needs.

• Your installation problems are solicited. Write for catalog and technical data. We also have technical and sales representatives in your area for your convenience. All standard items are shipped from stock the same day your order is received. Excellent service on "Specials".

Hydraulic Accessories

L&L MANUFACTURING CO.

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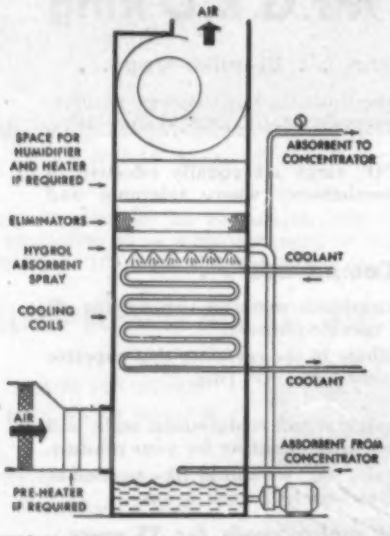
pound of air at 85 F dry bulb has been produced without refrigeration. Air is drawn through an enclosed casing, filtered and then passed through a spray of "Hygrol". Cooling coils in the same



NIAGARA CONTROLLED HUMIDITY METHOD — FLOW DIAGRAM

chamber remove the latent heat of evaporation as well as the specified amount of sensible heat. The air then passes through entrained moisture eliminators and diffused into the space to be conditioned. The absorbent liquid spray is piped from the chamber base tank to a concentrator which removes the moisture picked up from the air. The equipment can be used year around by using a tempering coil at the intake, a humidifier and a reheat coil above the eliminators. Sizes from 1000 to 20,000 cfm are manufactured. *10.*

Manual and Repeat Cycle Timer

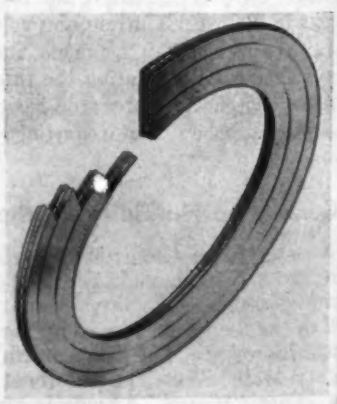
The "Cyclo-Flex" timer, an electronic timer which may be operated either single interval with manual initiation or as a repeat cycle timer with two adjustable intervals which occur successively, has been added to the line of controls offered by G. C. Wilson & Company. Each interval is accompanied by relay contact closure and is obtained by the charging of a resistance-capacitance network. The Cyclo-Flex timer may be used wherever interval timers are required. As a repeat cycle timer it is useful for valve pacing and many other applications. The new timer can be furnished with modifications as to time intervals, contact ratings and other features. The range of time intervals is ON ½ to 3 seconds, OFF 9 to 20 seconds. One stable, reliable vacuum tube is employed; the contactor of the electromagnetic relay is the only moving part. *11.*

Small Diameter Pipe Labels

A line of "Quik-Label" pipe markers for small pipe is announced by W. H. Brady Company. Designed for pipe sizes of ¼ in up to 2 in, labels are printed on the horizontal axis of a vertical starter-strip, small enough to be wrapped around the pipe. Over 150 different cards printed to ASA Standards are carried in stock. *12.*

High Pressure All-Metal Gasket

The Flexitallic Gasket Co. announces the development of a flexible, all-metal gasket for high pressure and high temperature applications. The new gasket is said to possess the advantages of solid metal without the rigid characteristics of ordinary solid metal gaskets; the gasket does not take a permanent "set", retaining resilience required to maintain a tight seal. The basic spiral-wound fea-



ture developed by this company is retained in the new gasket; several types of ferrous and non-ferrous metals are used in combination. A new basic thickness of .125 in is used, in addition to standard thicknesses. *13.*

Useful Literature

The publications listed are available without charge. Mark the initial key number on the card bound in this issue and mail.

28. Gauges . . . Catalog 76-I, available from Jas. P. Marsh Corporation, covers the complete line of Marsh industrial instruments. One section covers the design of Marsh gauges, another describes the five types of standard gauges offered, one important section covers industrial types, including three types of Mastergauges, five types of Quality gauges, double spring and hydraulic gauges, standard test gauges in two types and the duplex pressure gauge. One section is devoted to accessories including the "Racalibrator" and diaphragm attachments. A final section on specifications gives general specifications, case types and dial sizes, gauge dimensions and dial graduations.

29. Industrial Air Equipment . . . Catalog No. 49, issued by Air-Mite, lists the cylinders, valves, air arbor presses and air line fittings offered by this company. Both spring return and double acting cylinders in parallel thrust, vertical thrust, vertical face and clevis mounted models are illustrated and dimensional drawings and specifications given. Both single and double acting air arbor presses are shown, as well as representative valves, filters, regulators, oilers and air line fittings. A useful table of theoretical power conversion is also included.

30. Angle Hose Couplings . . . A four page bulletin issued by Avico, Inc., illustrates the line of integral hose couplings for aviation and industrial applications offered by this company. Couplings are available in six angles from 90 to 165 degrees, inclusive, by 15 degree increments for all hose sizes from 5/32 ID to 2 in ID. Both single wire braid reinforced hose for working pressures from 3000 to 500 psi and double wire braid reinforcement for high pressure applications from 4500 psi to 1000 psi are in the line.

31. Small Transmissions . . . Bulletin 67110, issued by The Oilgear Company, describes Oilgear fluid power variable speed small transmissions up to 3 hp. Each variable speed transmission, which consists of a volumetric, variable delivery, radial rolling piston pump driving a constant displacement radial rolling piston motor, has many applications in industry. The bulletin lists representative uses. Four standard types of controls; hand-screw, hydraulic servo-motor lever, hydraulic two-speed and electric three-position remote control are described and illustrated.

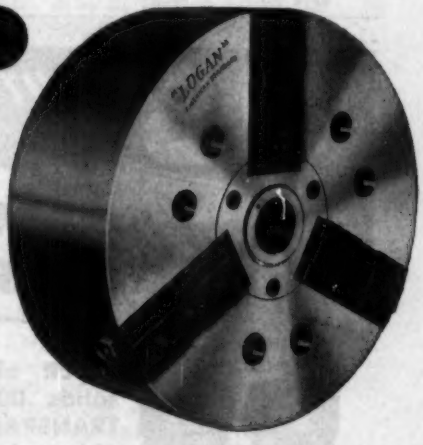
32. Air Valves . . . The Bellows Company has issued a 12 page bulletin AV100 on their line of standard air valves for remote control of single and double-acting air cylinders. In addition to standard four-way directional valves with built-in speed controls, series of 2, 3 and 4-way valves for remote control of standard air cylinders or for incorporation in existing air systems are shown and described. The valves, suitable for pressures up to 200 psi and operating temperatures to 120 F, are shown in button, lever, cam, clevis and foot operated types in sizes from ¼ in to ½ in in stock sizes and up to 1 in port sizes on order. Specifications and dimensional drawings are shown for each type.

33. Air-Cooled Compressors . . . Bulletin 753-3, made available to the trade by Chicago Pneumatic Tool Company, describes the 7½, 10 and 15 hp air-cooled compressors and a single stage vacuum pump, all designated as Class PB-20 equipment by this company. All units are of "V" type design;

* Fluid Power Improves Production

"LOGAN"

AIR AND HYDRAULIC POWER-OPERATED CHUCKS



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*FREE ENGINEERING SERVICE

Our engineers will solve your chucking problems with Logan special chucks, mandrels and collet chucks. No obligation.

• 32 years' engineering know-how • Completely equipped plant • Satisfaction assured • Complete range of standard types • Extra factors of strength and durability • Accurate, dependable service.

For your complete air and hydraulic chucking systems, Logan offers an extensive line of rotating cylinders, control valves, accessories, hydraulic power units and Collet Grip tube fittings.

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Air and Hydraulic Equipment

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FREE CATALOGS

Write for catalog No. 70, Section 1, on Logan air and hydraulic-operated chucks; catalogs Nos. 90 and 91 on air valves and cylinders.

CHUCKS • CYLINDERS • VALVES • PRESSES • SURE-FLOW COOLANT PUMPS

FLUID POWER SPECIALISTS SINCE 1916

a single acting, belt-driven unit in the three sizes is made in a single stage for pressures to 40 psi and two-stage for pressures to 175 psi. Standard equipment includes air intake filter and muffler, constant speed unloader and grooved wheel belt. Full specifications are given. The compressors are available in tank-mounted, base-mounted or bare models. The Class PB-20 vacuum pump is built in single-stage and two-stage designs, the latter recommended for a vacuum of 28 inches or higher.

34. "So You Want To Bend" . . . Wallace Supplies Mfg. Co. has issued their first catalog since 1937, "So You Want To Bend", a 40-page booklet covering their complete line. Featured are the automatic hydraulic bending machines of a wide range of design for many pipe, tube and bar bending requirements of industry. A number of special machines are shown. A number of pages are devoted to general engineering information on bending operations and techniques. A number of hand operated bending machines and fabricating tools are also shown.

35. Flexible Couplings . . . The American Flexible Coupling Co. has recently issued a booklet, "Relief From Bearing Wear Grief", in which they present a new engineering approach to the problems of a proper shaft coupling while compensating for misalignment. The well-illustrated 24-page booklet explains the causes of bearing failure, shaft failure, damaged equipment and resultant downtime, differentiates between types of stresses and presents the advantages of the non-flexible floating center member of their flexible couplings.

36. One Man Elevator . . . Bulletin CS 749, released by Ledeen Mfg. Co., describes and illustrates the use of a pneumatic actuating cylinder to operate a quick action, one-man elevator for a newspaper plant. A Ledeen 4 in diameter x 114 in stroke heavy duty cylinder was used to operate the one man elevator. Operation is controlled by a foot switch connected to a solenoid valve; 100 psi air pressure operates the cylinder.

37. Industrial Lubricating Equipment . . . Catalog No. 102, published by The Aro Equipment Corporation, covers the complete line of industrial lubricating equipment they manufacture. Low and high pressure air-powered single piston type and dual ratio

(Continued on page 36)

THE MARKET PLACE

CLASSIFIED ADVERTISING

Rates: For "Positions Wanted" $4.00 minimum, limit 25 words. For all other classifications $4.50 minimum for 25 words, each additional word 15c; bold face type or all capitals, $7.50 minimum for 25 words, each additional word 20c; limit 50 words. Box addresses count as five words. All insertions are payable in advance.

These columns are limited to Help Wanted or Position Wanted ads, and offerings of used equipment by the users of such equipment.

Hydraulic Cylinders, Double acting, 2½" Bore, 16½" travel, 1 3/16" shoft, ¼" pipe thread ports, Brand New $11.00 each, plus transportation. Shipping weight 10 pounds. Discount on ten or more. Spencer Aircraft, 8410 Dallas, Seattle, Washington.

PRACTICAL AIRCRAFT HYDRAULICS

51 COLORED illustrations. Diagrams of the DC-3, DC-6, Constellation, and Convair-Liner. Easy to understand. World Press, 1817 California Street, Denver, Colorado. $3.85 Postpaid.

"M-B" AUTOMATIC Air Line FILTERS and LUBRICATORS

FILTER element removes solids .00039 and larger. TRANSPARENT BOWL provides visibility. LUBRICATOR delivers desired volume of oil, no more, no less. Adjustable Venturi Valve permits efficient operation on broad range of volume and pressure . . . Bowl can be refilled without shutting off air supply. THESE DEVICES CAN BE USED AS SEPARATE UNITS OR IN COMBINATION.

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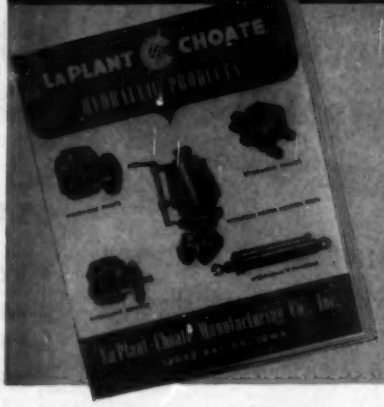
LaPLANT-CHOATE HYDRAULIC UNITS *AVAILABLE NOW* FOR YOUR HEAVY DUTY EQUIPMENT



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It's chuck-full of Construction Details, Performance Data, Dimension Drawings, Installation Data.

Here's valuable information on the complete line of LaPlant-Choate Hydraulic Products . . . hydraulic pumps, motors, valves, cylinders and compact 3-in-1 control units. The LaPlant-Choate Hydraulic line — result of 24 years' experience in building hydraulic controls for our own earthmoving and land-clearing equipment — is now available to provide safe, efficient and economical hydraulic power for your heavy duty equipment. Get the complete story — send for your copy of Bulletin A-1152F.

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APPLIED HYDRAULICS DIGEST

Abstracts, summaries and listings of articles on hydraulic and associated applications in industry; reports on prepared papers, talk and discussions pertinent to the hydraulics field.

Abstracts of Papers Delivered at the Fifth Annual National Conference on Industrial Hydraulics

"Hydraulics in Earth Moving Equipment", **By Morton M. Coker,** Caterpillar Tractor Co., Peoria, Ill.

This paper reviews the experience of this company in the manufacture of hydraulic power units as a result of a user demand for units which would approach or equal the performance of cable power units. While the primary use of these units is for bulldozer blade control, they are also used for controls on the scrapers on shovel type loaders.

Speed, power, long life, freedom from leaks and simplicity in servicing are objectives sought for in hydraulic power units. In attaining these objectives the hydraulic power units are sealed from atmosphere, have spring centered spool type control valves for ease of operation and vane type pumps for long life with little loss in pressure during life.

While tractor engine horsepower has increased from 15 to 20 per cent in the past 10 or 12 years, the increase in hydraulic power unit output has been from 50 to 200 percent. The speed of operation for hydraulically controlled bulldozer blades now approaches that of those controlled by cable units; the power in hydraulic units is sufficient to utilize all of the tractor weight in lifting effort. A number of the common difficulties associated with the use of hydraulic components on mobile equipment and methods of minimizing trouble from leakage, damage to exposed piping, servicing, etc. of units used in earth moving, road maintenance, lumbering, mining and numerous other types of operations were discussed. (This paper was delivered by J. E. Jass of the same company, due to illness of Mr. Coker.)

"Hydraulic Fluids, Petroleum and Synthetic", **By R. Q. Sharpe and C. W. Nichols, Jr.,** Socony-Vacuum Company, Inc., New York, N. Y.

The effectiveness of a hydraulic system is based upon the three fundamentals of proper circuit design, the precision and correctness of the mechanical parts and the ability of the hydraulic fluid to establish and maintain the operating cycle in proper sequence. The operating requirements that are affected by the hydraulic fluid are discussed with the characteristics of petroleum oils and their ability to meet these requirements. Latest

(Continued on page 37)

DUDCO'S EXTRA SMALL SERIES DUAL VANE PUMPS AND MOTORS

- **Pump sizes:** 3.5, 5, and 8 GPM for 2000 PSI Service
- **Motor sizes:** Up to 15 HP at 2000 RPM
- **Price:** $130.—again the best buy in the hydraulic field.

This new size completes Dudco's line of *continuous* duty hydraulic transmission Dual Vane Motors and Pumps. Single units are available up to 120 HP at 800 RPM for rugged reversing service where high stall torques are demanded.

DUDCO PUMPS AND MOTORS are used in mining machines, dry cleaning machines, oil derricks, conveyor drives, hydraulic presses, tapping machines, etc. where efficiency, ruggedness, and long life are at a premium; and oftentimes eliminates gear reduction units because of the motor SLOW SPEED-HIGH TORQUE capacity.

Engineering and application assistance is available from DUDCO'S Dealer ORGANIZATION located in most principal cities.

Send for literature of the DUDCO line of Pumps, Fluid Motors, and Power Units.

Dudco

PRODUCTS COMPANY

1799 E. NINE MILE RD., HAZEL PARK, MICH.

PHONE: JORDAN 4-6482

(Continued from page 34)

pumps, electric-powered lubricators, hand-operated high pressure type lubricators, low pressure hand and portable units, automatic speed couplers and connectors, high and low pressure hose assemblies and accessories are shown. Two models of the Aro line of gear type hydraulic pumps are also shown.

38. Air Cylinders . . . A new four-page bulletin, Form 1049, on the new T-J air cylinders with no tie rods, has just been issued by The Tomkins-Johnson Co. Features of design, mounting dimensions and data on the seven different styles made up to 8 in bore are briefly given. The full line of sizes, also offered in the tie rod types of air cylinders, is designed for the same range of operating pressures—80 to 100 psi.

39. Diaphragm Control Valves . . . Catalog V-2, issued by Hammel-Dahl Company, illustrates and describes the 3000 Series "Flo Tested" diaphragm control valves they manufacture. Design features, engineering data on valve flow characteristics and valve capacity, construction materials and applications are listed. The 3000 Series control valves are offered in sizes from ½ in to 12 in for general applications on air, water, oil, steam or gas. In addition to the standard, special diaphragm control valves, including three-way diaphragm, internal pilot balanced piston type diaphragm and packless diaphragm control valves are described and illustrated.

40. Higher Diols . . . An 8-page booklet, "Higher Diols", issued by Carbide and Carbon Chemicals Corporation, describes eight new glycols made by this company. Complete physical properties of the new diols are given, comparing them with the lower, more familiar 2- and 3-carbon glycols and glycerol. Uses have been tabulated by product and industry for quick reference. As a group these diols have applications as couplers or blending agents in hydraulic fluids, lubricants, brake fluids, cutting oils and metal cleaners.

Lindberg Air & Hydraulic Cylinders are available in a complete range of mountings—with any length of stroke.

★ Hydraulic Cylinders for pressures to 1500 PSI
★ Ten standard bore sizes from 2" to 8" inclusive
★ Standard air cylinders for pressures to 150 PSI
★ Mill-type heavy duty air cylinders for pressure to 250 PSI
★ Twelve standard bore sizes from 2" to 12" inclusive
★ Cushioned or non-cushioned
★ Non-rotating—double acting
★ Special cylinders built to order

Write for Bulletin 700, "Hydraulic Cylinders," or Bulletin AC-2, "Air Cylinders"

LINDBERG AIR & HYDRAULIC CYLINDERS

Lindberg Engineering Company, 2441 West Hubbard Street, Chicago 12, Ill.

CIRCLE NUMBERS ON THE CARD AND MAIL!

41. Packing Standards, Handbook . . . A new Handbook on Hydraulic and Pneumatic Packing Standards for Leather and Synthetic Rubber, the first to show J.I.C. "specs", has been issued by E. F. Houghton & Co. Types of packings, clearances and tolerances, new J.I.C. specification dash numbers on all Houghton items are shown. The number of sizes have been reduced. The new handbook supplements standard reference books on leather and synthetic rubber packings previously issued by this company.

42. Vacuum Pumps . . . Catalog No. 700, published by F. J. Stokes Machine Co., tells the complete, factual story of Stokes "Microvac" pumps. The engineering data on types of vacuum pumps and their selection for specific applications is excellent. The advantages of the "Microvac" high vacuum pumps, models available, specifications and applications photographs are included. A section on vacuum problems and their solution is worked out in detail. Some attention is also given to other Stokes equipment, particularly oil clarifiers, the McLeod gage for accurate measurement of high vacuum, the low pressure "Microjet" diffusion pump and the reciprocating vacuum pump.

43. Air Control Valves . . . Folder A, available from Valvair Corporation, is a brief illustrated check list of the various types of valves offered by this company. Also included is a series of cross sections of representative valves illustrating the air flow through valves and to indicate the open, closed and exhaust positions.

44. Double-Acting Air Cylinders . . . A new bulletin describing their Power Dome non-rotating, double-acting air cylinders has been just released by The Bellows Co. Complete data, including dimensional drawings and specifications, are given. The plain ported cylinders are made in both cushioned and non-cushioned types in bores of 2, 4, 6 and 8 in and any stroke length. Five mounting styles: foot or side, rear pivot, front flange, rear flange and trunnion mount are available.

45. Air Release Valves . . . Bulletin No. 140, issued by Simplex Valve & Meter Co., describes the standard and high pressure valves for separating air from water lines. Methods of installing air release valves on pipe lines and on pump casings are illustrated. Operation and construction are discussed in detail.

46. Industrial Catalog . . . A. Schrader's Son, Div. of Scovill Mfg. Co., Inc., temporary No. 10A catalog (not "the new industrial catalog") describes the Hydrodial hydraulic gauges offered by this company.

(Continued from page 35)

developments in hydraulic oils were reviewed and an outline of the classes of synthetic products now available was given.

Following the presentation of the general performance requirements, a summary of results of laboratory tests simulating hydraulic system operation was digested. Evaluations of both petroluem oils and synthetic products were covered briefly. (This paper was delivered by Mr. Nichols. Illness prevented Mr. Sharpe from attending.)

"Synthetic Fluids", **By J. M. Russ, Jr.,** Special Products Division, Carbide & Carbon Chemicals Corporation.

Mr. Russ' discussion was supplementary to the Sharpe and Nichols paper in that Mr. Russ discussed the "Ucon" types of lubricants useful as hydraulic fluids. He discussed both the water soluble series HB and the water insoluble LB series, reviewing their development and their ranges of applications to industrial equipment. He also discussed the hydrolube hydraulic fluids, including the H-4 fluid developed in cooperation with the Naval Research Laboratory and which was widely used on Naval aircraft during the war.

"Fire Resistance of Hydraulic Fluids and Hoses", **By J. J. Gassmann,** Civil Aeronautics Administration, Indianapolis, Indiana.

A discussion is presented of the flight fire hazards resulting from the complexity of modern aircraft hydraulic systems and the flammability of the present hydraulic fluids. The paper describes current efforts to reduce these hazards being made at the CAA Experimental Station, Indianapolis, Indiana.

A short-range project is in progress in which the objective is to promote the development and use of highly fire-resistant flexible metal hoses. Such hoses compare favorbly with the existing fabricated hoses from the standpoints of weight and flexibility. The superior fire-resistance of the all-metal hose as compared to that of the present fabricated hose becomes obvious. Methods of testing are described and comparative data are given.

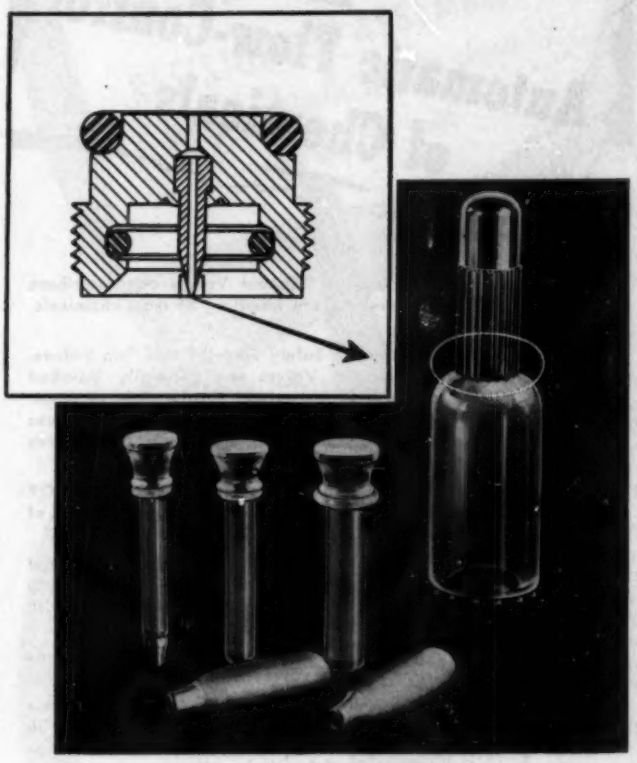
A long-range project is in progress in which development and use of relatively non-flammable hydraulic fluids are encouraged. Data are presented to described the relative ignitabilities of the highly flammable fluids presently used with those of the less flammable fluids under development.

Original fluid ignitability tests are discussed in which fluids were exposed to hot metal surfaces, electric sparks, and exhaust flames in an operating aircraft engine installation. Results of those tests are correlated with the results of tests conducted on a simple laboratory bench test developed for ignitability work.

"Theory and Practice in the Design of Hydraulic Seals", **By R. O. Isenbarger,** Chicago Rawhide Manufacturing Company, Chicago, Ill.

The development of hydraulic sealing theory was briefly traced and important design considerations, including speed, pressure, type of motion, sealed medium, contact surface finish, temperature, eccentricity and external conditions, were discussed. Often choice of

What has Cryotherapy to do with LINEAR "O" RINGS?



Simply this, Cryotherapy is the medical treatment of skin disorders by the use of carbon dioxide snow. Now this treatment is made practical—simple—effective—and economical by the invention of the Kidde Dry Ice Machine. This dry ice machine is made possible by the use of LINEAR "O" rings.* The "O" rings act as a seal between the neck of the gas cylinder and the cylinder piercing assembly. This assembly is in turn sealed to the discharge orifice with another "O" ring used as a static seal on three surfaces. LINEAR "O" rings are performing successfully on the Kidde Dry Ice Machine at pressures of 900 PSI and temperatures that momentarily drop to —110° F.

This is only one of the many outstanding examples of how LINEAR "O" rings are serving industry and humanity on land, on sea, and in the air—everywhere that packings must stand rigid use with many different elements and pressures under a wide range of temperatures. "O" Ring Packings, made of natural or synthetic rubber compounds, are precision molded to extremely close tolerances. They are available in standard sizes from ⅛" to 15½" I.D., and in special sizes as required. LINEAR engineering experience is at your disposal. May we serve you?

*The use of "O" rings in certain packing structures is covered by Christensen Pat. No. 2,180,795 under which we have paid the royalty for the installation of our rings in these structures so that the royalty is included in the purchase price of the "O" ring.

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design is dependent on minor considerations, so that all factors must be considered. The combined effect of all conditions that exist at one time determine the effectiveness of a seal.

The properties of seal materials, such as frictional properties, compressibility, elasticity, permanent set and impenetrability were reviewed. Seals are classified as static or dynamic—dynamic seals are grouped as rotary and/or reciprocating applications. By construction, they are classed as a single element or an assembly of parts; by type of contact, they are axial or radial.

General rules were given for various types of seals concerning their theory and range of conditions in which they can be operated. Compression, jam and pressure actuated seals are of a single element, normally used for reciprocating applications. Seals for rotary shafts take two forms, axial and radial, depending on the direction of the contact pressure. Points to watch, which were discussed in detail, included proper contact at static surface (press fit or bolting), alignment, seal damages in assembly, initial lubrication, cleanliness, proper storage and handling.

"Some Applications of Fluid Mechanics to Mixing", **By J. H. Rushton,** Illinois Institute of Technology, Chicago, Ill.

The mixing of liquids in vertical cylindrical vessels by means of rotating impellers (sometimes called agitators) is an important operation in the process industries. Application of fundamental principles of fluid mechanics is essential to a proper understanding of the mechanical effects and requirements necessary to evalu-

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ate the performance of mixing equipment. Chemical reactions are often dependent upon mixing, and thus upon the fluid regime present in the mixing tank.

The mechanics of similitude and model techniques applicable to mixing operations are outlined. A general relation is developed by dimensional analysis in terms significant to rotating impeller mixing systems. The power characteristics of several types eof mixing impellers are given in terms of dimensionless groups in the form of curves obtained from experimental data.

"The Berry System of Hydraulic Power Conversion", **By Frank Berry,** Berry Motors, Inc., Corinth, Miss.

The paper describes the basic considerations, the hydraulic screw principle and the inherent advantages of the Berry converters and reviews the development of this type of equipment over a period of 20 years.

The flexibility of the system and the arrangements of valving used in various power transmission were explained. The comparison of pulsation measurements made on various types of converters were shown, as well as details of independent test data. The paper concluded with examples of many applications of the system with presentation of circuit diagrams, flow curves and power transmission data.

"Development of the Constellation Hydraulic System", **By Robert R. Richolt,** Lockheed Aircraft Corporation, Burbank, California.

A specially prepared extract from this paper is in the Aviation Hydraulics section of this issue.

(To be continued in the next issue)

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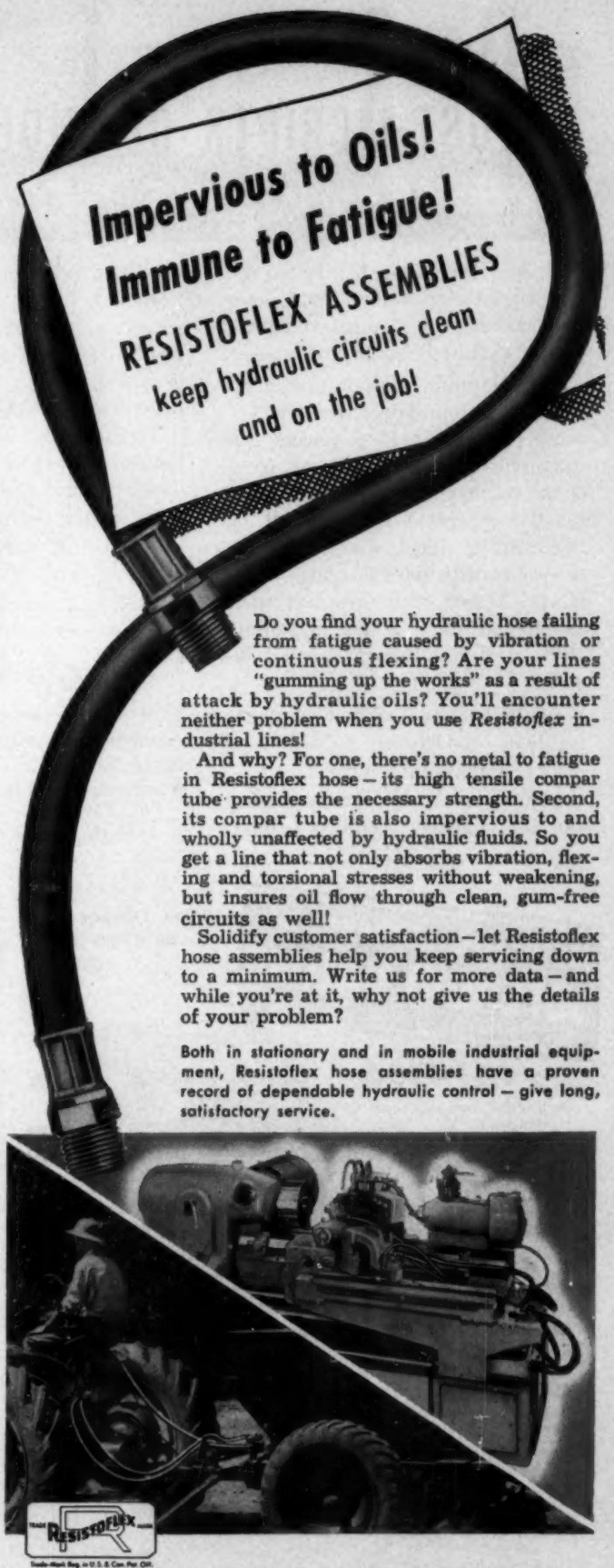

Do you find your hydraulic hose failing from fatigue caused by vibration or continuous flexing? Are your lines "gumming up the works" as a result of attack by hydraulic oils? You'll encounter neither problem when you use *Resistoflex* industrial lines!

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POST SCRIPTS OF INDUSTRY

NEWS · VIEWS · TRENDS

H. A. "Hap" Price has joined the sales engineering staff of The Rucker Co., Oakland, Calif., as sales engineer for the Oakland-Sacramento area.

The Hannifin Corporation, Chicago, held a four day conference, November 4-7, of field engineers and sales representatives from all parts of the country. The conference, personally organized by Ellwood G. Peterson, president, was held in the new plant with sales meetings under H. H. Adams, vice president-sales, and engineering staff meetings under Otto J. Maha, vice president-engineering.

At the annual stockholders' meeting held on October 10th, Goshen Rubber and Manufacturing Co., Inc., elected Elmo E. Niccum, president and sales manager; William J. Johnson, vice president and treasurer; Vernon J. Pease, vice president and secretary; and Joseph S. Royal and Richard G. Bigler as directors. Wayne E. Burger was named corporation comptroller at the same time.

The first Plant Maintenance Show, sponsored by the American Society of Mechanical Engineers and the Society for the Advancement of Management, will be held January 16-19 at Public Auditorium, Cleveland.

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- Poppet design eliminates leakage
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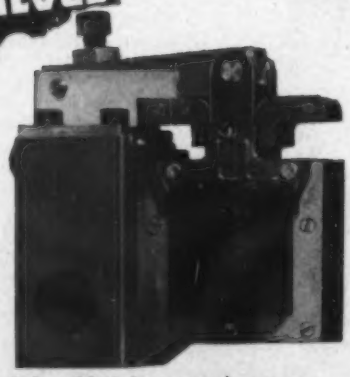

Waterman High Pressure Solenoid Valves are inexpensive, compact units designed for continuous duty in hydraulic systems where pressures are as high as 3000 P.S.I. Poppet type construction gives positive sealing against internal leakage. Impregnated oil resistant coils make these valves suitable for mounting in oil reservoirs. In many cases this feature eliminates costly piping and makes possible the construction of smaller, more compact hydraulic power units. Available in ⅜" pipe size. Electrical requirements are 110 volt—60 cycle A.C. current.

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